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XLI. *On the Anatomy and Physiology of the Spongiadæ.*—Part III. *On the Generic Characters, the Specific Characters, and on the Method of Examination.*

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WHILE the arrangement of other branches of natural history has occupied the attention of some of the most laborious and talented naturalists of every age, the Spongiadæ appear to have scarcely attracted sufficient attention to excite any writer on natural history to a serious attempt at a systematic classification. This neglect has not arisen from any incapacity for a definite arrangement on the part of the Spongiadæ, as the organic differential characters of the numerous groups into which, by careful examination, they may be readily divided are as varied and as widely removed from each other as are the strikingly distinct and well defined divisions of the Corallidæ; and the number of species I believe to be very much greater than those of the latter class. Of British species alone I am already acquainted with 150 or more; and new ones are continually being discovered by the aid of the dredge. It becomes therefore a matter of necessity that we should classify their permanent varieties of structure, and found on them a series of orders, suborders, and genera, and through these subdivisions become enabled to recognize more readily the very numerous species of these animals which abound in all parts of the world.

DE BLAINVILLE proposed to include the whole of the Spongiadæ under the designation of Amorphozoa; but this term is objectionable, as all sponges cannot be considered as shapeless—on the contrary, many genera and species exhibit much constancy in their form. Neither can the term be justly applied to their internal structure, as we find in *Grantia*, *Geodia*, *Tethea*, and other genera regular and systematical structures which are very far removed from shapelessness. I have therefore thought it advisable to adopt Dr. GRANT'S designation of Porifera, a term which embraces the whole of the Spongiadæ, and which is truly descriptive of the most essential general action of the animal's power and mode of imbibing nutriment, which in every species with which I am acquainted is, by a series of minute pores distributed over the external membrane of the sponge.

Besides this universally existent character there are others which are strikingly characteristic of the class, although not so universally prevalent as the porous one. Thus the skeletons of the Spongiadæ are always internal, but in the material and mode of construction they vary to a very considerable extent. Sponges may therefore be defined as fixed, aquatic, polymorphous animals, inhaling and imbibing the surrounding element through numerous contractile pores situated on the external surface; conveying it

through internal canals and ejecting it through appropriate orifices; having an internal flexible or inflexible skeleton composed of either carbonate of lime, silex, or keratode; with or without either of these earthy materials. Calcareous skeletons always spicular. Siliceous skeletons either spicular or composed of solid, laminated, and continuous siliceous fibre.

Propagation by ova, gemmulation, or spontaneous division of its component parts.

Dr. GRANT, in his learned and elaborate "Tabular View of the primary divisions of the Animal Kingdom," published in 1861, has divided the Porifera into three orders, based on principles which I have adopted. The first order is *Keratosa*, in which the skeletons are essentially keratose and fibrous; the second, *Leuconida*, is composed of the calcareous sponges; and the third, *Chalinida*, consisting of the siliceous sponges. I have not adopted the full and precise definition of each of these Orders as given by the learned Professor, as, if the whole of the distinctive characters in the first and third of them were insisted on in the determination of the orders to which many exotic species belong, it would lead in numerous cases to inextricable confusion. The term *Leuconida* is also objectionable, as all calcareous sponges are not white, and colour is at best but a very uncertain character even in the determination of a species; I have therefore adopted the principles of the arrangement of Professor GRANT, with the following modifications of position and descriptions of the characteristics of each order.

1. CALCAREA. Sponges the skeletons of which have as an earthy base carbonate of lime.

2. SILICEA. Sponges in which the earthy base consists of siliceous matter.

3. KERATOSA. Sponges in which the essential base of the skeleton consists of keratose fibrous matter.

While thus assuming the principles of arrangement enunciated by the learned Professor, I have been induced to vary the mode of the disposition of his Orders from the following considerations.

In the highest vertebrated animal types we invariably find the skeleton principally composed of phosphate of lime with a small portion of carbonate of lime and other substances, the whole consolidated by cartilage. As we descend the scale of the Vertebrata we find the salts of lime decrease in proportional quantity until they occur in minute detached patches only, and cartilage becomes the essential base of the skeleton.

In the great tribe of Mollusca we find carbonate of lime prevailing in their shells to the exclusion of phosphate of lime, and in the compound Tunicata we have a structure analogous to that of the cartilaginous tribe of Fishes. In the massive subcartilaginous body of this tribe there is no continuous or connected earthy deposit; this material of the skeleton exists only in the form of detached masses of radiating spicula. As we descend in the animal scale we find carbonate of lime entirely absent, and silex replacing it in the elaborate and beautifully constructed lorice of the marine and freshwater infusoria.

If we are to reason from these gradations of structure and apply our reasoning to the

Spongiadæ, we should then give precedence to the calcareous sponges as representing in the class the highest order of secretive power; and if we add to these considerations the regularity of structure and function and the full development of ciliary action that exists in *Grantia ciliata* and *compressa* and the allied species, I think it scarcely allows of a doubt that this order should take precedence of the others in an arrangement of the Spongiadæ.

The siliceous sponges naturally follow in succession, and the Keratosæ, as indicated by their imperfect secretive powers and their low order of organization in other respects, would stand the last in the series.

*On the Generic Characters of the Spongiadæ.*

The foundation of the genera of the Spongiadæ has hitherto been based principally upon form and other external characters of an equally unstable description, and in many instances genera have been named without the slightest attempt to characterize them. As a generic character, form is inadmissible, inasmuch as each variety of it is found to prevail indiscriminately in genera differing structurally to the greatest possible extent.

I will not enter on the history of the genera that have been proposed by previous writers on the Spongiadæ, as the greater portion of those which have been published will hereafter be found to have been adopted, with certain revisions of their characters, in the series of genera I propose to establish, but I shall beg to refer such of my readers as may be desirous of further information on that subject to page 70 of Dr. JOHNSTON'S admirable introduction to his 'History of British Sponges and Lithophytes.'

Having thus rejected form and other external characters as the foundation of generic descriptions, we naturally resort to the anatomical peculiarities of the animal for these purposes; and here fortunately we find a variety in structure and form, and a constant adherence to their respective types that admirably adapt them to our purpose.

If any portion of the animal remains whereby we may recognize it as one of the Spongiadæ it is always the skeleton; and it is therefore advantageous to adopt this most persistent portion of the animal as the foundation of our generic descriptions. But this is not the sole reason for such a conclusion, as it is not only the most enduring portion of the animal, but it is also the most undeviatingly regular in the form and arrangement of its component structures. However great may be the variations that exist in size and form between different species of the same genus, or between individuals of the same species, the characteristic tissues of their skeletons are always found to harmonize in their structural peculiarities. It appears, therefore, advisable in these animals, as well as in the higher classes, to select the skeleton as the primary source of generic distinctions. Other portions of the permanent organs may be occasionally resorted to when necessary as auxiliary characters, such as the incurrent and excurrent canals, the intermarginal cavities, the cloaca, and the various modes of reproduction. Each of these characters is of use in generic descriptions to a certain extent; but none of them is absolutely

necessary to the determination of a genus, and occasionally we find one or more of these modes of organization entirely absent; we may therefore consider them not as primary, but rather as secondary or auxiliary generic characters.

I therefore propose to consider the varieties in the construction of the skeleton as the foundation or primary source of division into genera, and to dedicate that portion of the animal especially to that purpose, the auxiliary or secondary characters being resorted to only when required to aid and assist the primary ones; and it is only to a very limited extent that they are in reality available. Thus the cloaca in the Order Calcarea becomes a very important means of generic distinction, and in some cases in the Order Keratosa it is also a prominent character, while in Silicea it is generally absent. In some species of this order, as in *Alcyoncellum*, *Polymastia*, and *Halysphysema*, it assumes a normal character, while in several species of *Halichondria*, as in *H. panicea*, it assumes very striking proportions in excessively developed specimens, whilst in others it is either an occasional, uncertain, and progressive organ, or is altogether absent.

The mode of propagation is also an uncertain character. Thus in *Tethea cranium* we find it to be by internal gemmulation, in *T. Lynceurium* by external gemmules, and in other species of the genus no gemmules of any description have hitherto been detected. In *Geodia*, *Pachymatisma*, and *Spongilla* the general structure and mode of disposition of the ovaria render them valuable auxiliary generic characters, but in other cases they are of little or no value.

The intermarginal cavities are available as generic characters in *Geodia* and the nearly allied species; and in the same sponge the relative position of the connecting spicula form good distinctive characters in the genera *Geodia*, *Ecionemia*, and also some of the siliceo-fibrous sponges. In *Alcyoncellum*, *Polymastia*, and *Geodia* the position and appendages of the oscula are also available; but generally speaking those organs are so mutable as to render them of little value as generic characters.

The following tabular view of the arrangement I propose to adopt will perhaps render the details regarding the distinctive characters and natural affinities of the genera more readily comprehensible.

*Tabular View of Systematic Arrangement.*

Class.	Order.	Suborder.	Genera.
PORIFERA.	I. CALCAREA.		Grantia, <i>Fleming</i> . Leucosolenia, <i>Bowerbank</i> . Leuconia, <i>Grant</i> . Leucogypsia, <i>Bowerbank</i> .
	II. SILICEA.	1. Spiculo-radiate skeletons .....	Geodia, <i>Lamarck</i> . Pachymatisma, <i>Bowerbank</i> . Ecionemia, <i>Bowerbank</i> . Alcyoncellum, <i>Quoy et Gaimard</i> . Polymastia, <i>Bowerbank</i> . Halyphysema, <i>Bowerbank</i> . Ciocalypa, <i>Bowerbank</i> . Tethea, <i>Lamarck</i> . Halicnemina, <i>Bowerbank</i> . Dictyocylindrus, <i>Bowerbank</i> . Phakellia, <i>Bowerbank</i> . Microciona, <i>Bowerbank</i> . Hymeraphia, <i>Bowerbank</i> . Hymedesmia, <i>Bowerbank</i> . Hymeniacidon, <i>Bowerbank</i> . Halichondria, <i>Fleming</i> . Hyalonema, <i>Gray</i> . Isodictya, <i>Bowerbank</i> . Spongilla, <i>Linnaeus</i> . Desmacidon, <i>Bowerbank</i> . Raphyrus, <i>Bowerbank</i> . Diplodemia, <i>Bowerbank</i> . Dactylocalyx, <i>Stutchbury</i> . Farrea, <i>Bowerbank</i> .
	III. KERATOSA.	1. Solid non-spiculate kerato-fibrous skeletons ... 2. Solid semispiculate kerato-fibrous skeletons ... 3. Solid entirely spiculate kerato-fibrous skeletons ... 4. Simple fistulo-fibrous skeletons .....	Spongia, <i>Linnaeus</i> . Spongionella, <i>Bowerbank</i> . Halispurgia, <i>Blainville</i> . Chalina, <i>Grant</i> . Verongia, <i>Bowerbank</i> . Auliskia, <i>Bowerbank</i> . Stematumenia, &c., <i>Bowerbank</i> . Dysidea, <i>Johnston</i> .

## Order I. CALCAREA.

The number of species of calcareous sponges that are known is comparatively so small, and the four genera into which I have divided them are naturally so well characterized, as to render the establishment of suborders unnecessary. Hereafter, when we are acquainted with a greater number of species, and other varieties of organization become known, the genera now established may become the types of suborders, for which office their distinctly different modes of construction render them eminently efficient.

Although the calcareous structure of the species of this order appears to entitle it to precedence in the arrangement of the Spongiadæ, it does not maintain in the structure of its skeleton throughout the whole of the genera the same high type of formation

that is exhibited in *Grantia compressa* and the allied species, and we observe a progressive decline in regularity of structure in its genera very analogous to what we find existing among the Halichondroid tribe of sponges; but in this respect they only follow the same laws of gradual degradation that obtain in every other class of created beings; and therefore this gradual decline in regularity of structure should not militate against the claim of even the lowest in organization of the tribe from taking precedence of the siliceous sponges.

Dr. GRANT was the first naturalist who decided that the spicula of a certain group of small sponges were composed of carbonate of lime, and he separated them accordingly from those the spicula of which were siliceous, and assigned to them the generic name of *Leucalia* (Edinburgh Encyclopædia, vol. xviii. p. 844); and subsequently, in his 'Outlines of Comparative Anatomy,' he changed that name to *Leuconia*. In 1828 Dr. FLEMING gave to the group the name of *Grantia*, in compliment to the learned naturalist who had first pointed out their peculiar structure.

A careful examination of the British species of this Order will very soon satisfy a naturalist that there are at least four distinct forms in the organization of the skeleton, and that each is fully entitled to generic distinction. Thus in *Grantia ciliata* and *compressa*, Johnston, we find the sponge to be constructed of a series of cells, each having separate parietes, and extending from the dermal surface to near the inner surface of the sponge, where they discharge the faecal streams into a common cloacal cavity. In *Grantia botryoides*, Johnston, the system of cells is entirely wanting; the sponge is composed of a single thin stratum of membranous structure and spicula, surrounding a large cylindrical cloacal cavity, from the terminations of which the faecal streams are discharged. In *Grantia nivea*, Johnston, we find the sponge massive and irregular in form, containing numerous capacious cloacal cavities, each terminated by a single large mouth, the interstitial structures between the sides of these great cavities and the dermal surfaces of the sponge consisting of irregularly disposed membranes and spicula, permeated by contorted interstitial cavities, terminating in simple orifices or oscula in the sides of the great faecal cavity into which they discharge their excurrent streams; and in *Leucogypsia Gossei*, Bowerbank, MS., the sponge is massive, without cloaca, formed of irregularly disposed membranous tissues and spicula, and with oscula at the external surface, thus simulating to a great extent the mode of structure of the Halichondroid tribes of sponges.

The sponges of this Order appear to possess a high degree of vital power, and I have rarely failed in finding the excurrent orifices in vigorous action in either *Grantia compressa*, *ciliata*, or *botryoides* when recently taken from the sea. In *G. compressa*, especially, I have often observed the inhalant and exhalant actions remarkably vigorous; and if a drop of water containing finely comminuted indigo be mixed with the water in which they are immersed, they will become deeply tintured with it in a very few seconds. This vigorous action is accounted for by the highly developed ciliary system, which may be readily seen in action if the sponge be carefully split open and immersed in fresh cold

sea-water, and examined with a power of about five or six hundred linear by transmitted light. The cilia will be seen in rapid action just within the oscula which terminate each of the large angular interstitial cells of the sponge. This action, and the mode of the disposition of the cilia within the cells, I have described at length in the Transactions of the Microscopical Society of London, vol. iii. p. 137, plate 19. In accordance with these variations in structure I purpose dividing the British species into four genera.

Class **PORIFERA**, Grant.

Order I. **CALCAREA**.

Genera. *Grantia*.

*Leucosolenia*.

*Leuconia*.

*Leucogypsia*.

**GRANTIA**, Fleming.

Sponge furnished with a central cloaca, parietes constructed of interstitial cells, more or less regular and angular in form, disposed at right angles to the external surface, and extending in length from the outer to very near the inner surface of the sponge, where each terminates in a single osculum.

Type, *Grantia compressa*, Johnston.

The cloaca varies in its form and proportion. In some species it has invariably one large terminal mouth, while in others it is furnished with several mouths, from which the excurrent fæcal streams are discharged.

The interstitial structures of the sponges of this genus assume a greater amount of regularity than is found to exist in any other genera of these animals. The whole of the parietes of the sponge are formed of somewhat angular cells, the sides of which belong to the individual cell, and are not common to the adjacent cells. The length of the cells in proportion to their diameter varies in different species, and also in the same species in proportion to the age and thickness of the parietes of the sponge. The cell-walls are formed of comparatively stout transparent membrane, strengthened and supported by numerous triradiate spicula; and the whole length of the cell, from the inner edge of the osculum to near the outer surface of the sponge, is closely studded with tessellated nucleated cells, each of which is furnished with a long attenuated cilium. Each interstitial cell terminates in a single osculum, slightly within the plane of the inner surface of the sponge. I do not remember to have ever seen these oscula entirely closed. When the inhalant action of the sponge is in vigorous operation, the excurrent streams may be seen issuing from them with considerable force, and the cilia appear in action immediately within them.

Hitherto the mouths of the great cloacal cavity of the sponges of this tribe have been described as oscula; but if we carefully examine the structure of these and similarly

formed sponges, we shall find in all cases that those organs exist only on the inner surface of the great cloacal cavities.

The construction of the interstitial cells is best demonstrated in a longitudinal section of a dried specimen of *Grantia ciliata*, mounted in Canada balsam; and in a specimen so prepared, spaces are seen between the cells, which are often nearly half the size of the cells. These spaces are most probably produced by the contraction of the tissues induced by the mode of the preparation of the object, and do not exist in the living sponge; but they serve admirably to demonstrate the fact that each interstitial cell has its own special parietes, and that the divisions between the cells are not common to adjacent cells. Plate LXXII. fig. 1, and (Part II.) Plate XXXIII. figs. 1 & 2.

LEUCOSOLENIA, Bowerbank.

*Grantia*, Fleming and Johnston.

Sponge fistular, formed of a single layer of triradiate and other spicula surrounding a large central cloaca, which extends into all parts of the sponge.

Type, *Grantia botryoides*, Fleming.

The structure of *Grantia botryoides*, Fleming, differs essentially from that of *Grantia compressa* of that author, inasmuch as there is a total absence of the interstitial cells which are so characteristic of the latter sponge; and its structure is equally discrepant when compared with that of *Grantia nivea* of Fleming; for although it possesses cloacæ in common with that species, it has no approximation whatever to the massive Halichondroid form of the substance of that sponge. On the contrary, its parietes consist of a single thin layer of spicula and membranous tissues surrounding a large central sinuous cloaca. Plate LXXII. fig. 2.

LEUCONIA, Grant.

*Grantia*, Fleming and Johnston.

Sponge furnished with cloacæ, one or more. Parietes of sponge formed of a mass of irregularly disposed interstitial membranes, and triradiate and other spicula; permeated by sinuous excurrent canals, the oscula of which are irregularly disposed over the surfaces of the cloacæ.

Type, *Grantia nivea*, Fleming.

*Grantia nivea* of Dr. Fleming is very different in its structure from either *G. compressa* or *ciliata*, or of *G. botryoides* of that author. It has not the regular interstitial structure of either of the first two, nor the simple fistulose form of the latter one, but, with the exception of the form of the spicula, it closely simulates the structural character of the siliceous genus, *Halichondria*, while it is allied with the before-named calcareous sponges by the possession of cloacæ. In consequence of these marked differences in the structure of the skeleton, I have separated it from *Grantia* as defined by Dr. FLEMING, and constituted it a genus, adopting the term *Leuconia*, which was proposed by Dr. GRANT as a general designation of the whole tribe of calcareous sponges. Plate LXXII. fig. 3.

## LEUCOGYPSIA, Bowerbank.

Sponge massive, without cloacæ; formed of irregularly disposed membranous tissues and spicula. Oscula at the external surface.

The sponges of this genus are still further removed in structural character from the more highly organized genera of calcareous sponges *Grantia* and *Leucosolenia* than the genus *Leuconia* is. In the arrangement of the interstitial membranes, and the mode of dispersion on them of the skeleton-spicula, there is a manifest similitude to the structural peculiarities of the genus *Hymeniacidon* among the Silicea, and we find a corresponding simplicity in the characters of the spicula, in *Leucogypsia* the type of this genus. There are no regularly determined cloacæ projected from the surface as in *Leuconia*; and the excurrent canals of the sponge merge into each other, until they unite in one large canal immediately beneath the osculum, in the manner generally prevailing in the great mass of Halichondroid sponges. These large canals have defensive spicula similar in structure to those of the other genera of calcareous sponges. The only known British species of this genus is *L. Gossei*, Bowerbank, MS.; but I am acquainted with an exotic species, *L. algoaensis*, Bowerbank, MS., which is not uncommon on specimens of Zoophytes and Fuci from Algoa Bay and its neighbourhood. Plate LXXII. fig. 4.

*Synopsis of the Suborders of the SILICEA and KERATOSA.*

## Order II. SILICEA.

Suborder I. Spiculo-radiate skeletons. Not reticulate. Composed of spicula radiating in fasciculi or separately from the base or axis of the sponge.

- |   |   |
|---|---|
| 1. <i>Geodia</i> , Lamarck.               | 8. <i>Tethea</i> , Lamarck.             |
| 2. <i>Pachymatisma</i> , Bowerbank.       | 9. <i>Halicnemis</i> , Bowerbank.       |
| 3. <i>Ecionemia</i> , Bowerbank.          | 10. <i>Dictyocylindrus</i> , Bowerbank. |
| 4. <i>Alcyoncellum</i> , Quoy et Gaimard. | 11. <i>Phakellia</i> , Bowerbank.       |
| 5. <i>Polymastia</i> , Bowerbank.         | 12. <i>Microcionia</i> , Bowerbank.     |
| 6. <i>Halyphysema</i> , Bowerbank.        | 13. <i>Hymenaphia</i> , Bowerbank.      |
| 7. <i>Ciocalyptra</i> , Bowerbank.        | 14. <i>Hymedesmia</i> , Bowerbank.      |

Suborder II. Spiculo-membranous skeletons. Composed of membranous structure, having spicula irregularly dispersed on their surfaces.

*Hymeniacidon*, Bowerbank.

Suborder III. Spiculo-reticulate skeletons. Skeletons continuously reticulate in structure, but not fibrous.

1. *Halichondria*, Fleming.
2. *Hyalonema*, Gray.
3. *Isodictya*, Bowerbank.
4. *Spongilla*, Linnæus.

Suborder IV. Spiculo-fibrous skeletons. Regularly fibrous. Fibres filled with spicula.

1. *Desmacidon*, Bowerbank.
2. *Raphyrus*, Bowerbank.

Suborder V. Compound reticulate skeletons, having the primary reticulations fibro-spiculate, and the interstices filled with a secondary spiculo-reticulate skeleton.

*Diplodemia*, Bowerbank.

Suborder VI. Solid siliceo-fibrous skeletons, reticulate. Fibres composed of concentric layers of solid silex; without a central canal. Reticulations unsymmetrical.

*Dactylocalyx*, Stutchbury=*Iphiteon* of the Museum at the Jardin des Plantes, Paris.

The structure of the fibre in this suborder of siliceo-fibrous sponges is equivalent to that in the first suborder of the third order, Keratosa.

Suborder VII. Canaliculated siliceo-fibrous reticulated skeletons. Fibres composed of concentric layers of solid silex, with a continuous central canal. Reticulations symmetrical.

*Farrea*, Bowerbank.

The construction of the fibre of the skeletons of this suborder of siliceo-fibrous sponges is the equivalent of the fibrous structure of the fourth suborder of the third order, Keratosa.

### Order III. KERATOSA.

Suborder I. Solid non-spiculate kerato-fibrous skeletons.

1. *Spongia*, Linnæus.
2. *Spongionella*, Bowerbank.

No spicula are secreted in any of the parts of the sponges of this suborder.

Suborder II. Solid semispiculate kerato-fibrous skeletons. Skeleton partially symmetrical; primary lines of fibre radiating from the proximal to the distal parts of the sponge; fibres containing spicula. Secondary lines of fibres unsymmetrical, destitute of spicula.

The Bahama sponges of commerce are most of them members of this suborder.

*Halispongia*, Blainville.

Suborder III. Skeletons kerato-fibrous; fibres solid, entirely interspiculous. Skeleton symmetrical.

*Chalina*, Grant.

In this suborder the keratode is the primary material in the structure of the fibre, and the spicula the secondary or auxiliary agent. The reverse is the case in the spiculo-fibrous tissues of the fourth suborder of Order II. Silicea.

Suborder IV. Simple fistulo-fibrous skeletons. Cavity of the fibre simple, central, and continuous.

*Verongia*, Bowerbank.

*Spongia fistulosa*, Lamarck.

The genus *Verongia* was described by me in the Annals and Magazine of Natural History for May and December 1845.

The same relative differences exist between the fibrous structures of the suborders six and seven of the second order, Silicea, that we observe between those of the first and fourth suborders of the third order, Keratosa.

Suborder V. Compound fistulo-fibrous skeletons. Central cavity of the fibre single and continuous, having secondary cæcoid branches radiating from it at nearly right angles.

*Auliskia*, Bowerbank.

This genus was described by me in the Annals and Magazine of Natural History for May and December 1845.

Suborder VI. Regular semi-areno-fibrous skeletons. Skeleton regularly areno-fibrous, having a well-defined central line of grains of extraneous matter within the fibres.

*Stematumenia*, Bowerbank.

In the sponges of this suborder the extraneous material is subordinate to the keratose fibre, in which it exists in the form of a central line of sand or other extraneous matters, constituting an axial line in the fibre surrounded by a thick coat of pure keratode. The axial line of sand is generally confined to the primary fibres of the skeleton, the secondary ones being usually without it. A portion of the commonest Bahama sponges of commerce belong to this order.

Suborder VII. Irregular and entirely areno-fibrous skeletons. Skeleton irregularly areno-fibrous, having the skeleton-fibre filled from the centre to the surface with grains of extraneous matter.

*Dysidea*, Johnston.

In the skeletons of the sponges of this suborder the keratode appears subordinate to the extraneous matter; the fibres frequently appearing to consist almost entirely of sand.

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#### *On the Arrangement of the Genera.*

The genus *Halichondria*, as established by FLEMING and adopted by Dr. JOHNSTON, when applied to the arrangement of exotic as well as British species, embraces so wide a range as to afford little or no assistance in the determination of species. Under this designation every known sponge would be arranged having siliceous as the earthy basis of its skeleton, however varied their anatomical structure might be, excepting the few species contained in the genera *Geodia*, *Tethea*, and *Spongilla*.

Dr. JOHNSTON, in his 'History of British Sponges,' has divided the British species into

three sections, dependent on their form, a character so mutable among the Spongiadæ, as to render it of little value, under any circumstances, when unaccompanied by structural peculiarities. I have therefore thought it advisable to distribute the genera included in the order Silicea among seven suborders, founded on the most striking peculiarities of the structure of the skeleton.

The first of these will consist of sponges having spiculo-radiate skeletons. Skeletons not reticulated, but composed of spicula radiating in fasciculi or separately from the base or axis of the sponge. This order will contain as many as fourteen distinct genera, the whole of which have skeletons the spicula of which are arranged in radial order. The mode of the radiation in these fourteen genera is not precisely the same, but they form three closely according groups, of which the leading genus of each of the first two may be considered as the type.

- |   |                                    |
|---|------------------------------------|
| 1. <i>Geodia</i> , Lamarck.               | 5. <i>Polymastia</i> , Bowerbank.  |
| 2. <i>Pachymatisma</i> , Bowerbank.       | 6. <i>Halyphysema</i> , Bowerbank. |
| 3. <i>Ecionemia</i> , Bowerbank.          | 7. <i>Ciocalypta</i> , Bowerbank.  |
| 4. <i>Alcyoncellum</i> , Quoy et Gaimard. |                                    |

The second group contains:

- |                                   |  |
|-----------------------------------|--|
| 1. <i>Tethea</i> , Lamarck.       | 3. <i>Dictyocylindrus</i> , Bowerbank. |
| 2. <i>Halicnemis</i> , Bowerbank. | 4. <i>Phakellia</i> , Bowerbank.       |

In the whole of the first two groups, excepting *Halyphysema*, the skeleton-radiations are fasciculated to a greater or a less amount in the different genera.

The third group will comprise:

1. *Microciona*, Bowerbank.
2. *Hymenaphia*, Bowerbank.
3. *Hymedesmia*, Bowerbank.

The most striking general character in these three genera is the extremely thin coating-form of the sponge, and the radiation of the skeleton-spicula, either singly or in an irregularly fasciculated form, from a common basal membrane, the thickness of the sponge in some of the species being less than the length of one of the radiating skeleton-spicula.

## Order II. SILICEA.

Suborder I. Spiculo-radiate skeletons. Not reticulate. Composed of spicula radiating in fasciculi or separately from the base or axis of the sponge.

### GEODIA, Lamarck.

Skeleton: spicula fasciculated, radiating from the base or central axis of the sponge to the surface. Dermis crustular, furnished abundantly with closely packed ovaria. Ovaria siliceous, composed of cuneiform spicula, firmly cemented together by silex, in lines radiating from the centre of the ovary. Pores furnished with œsophageal tubes \*

\* *i. e.* tubes resembling in their office the œsophageal tubes of the higher animals. The expression "pyloric valve" used further on is to be understood in a similar sense.

terminating in the distal extremity of the intermarginal cavities. Intermarginal cavities separate, symmetrical, subcylindrical; each furnished with a membranous valve at its proximal extremity.

The genus, as described by LAMARCK\*, is so loosely characterized that I have thought it better to reconstruct it entirely than to endeavour to amend it. I have therefore given a new series of characters, founded solely on its structural and organic peculiarities. I am acquainted with seven species, all of which perfectly agree in the essential generic characters as thus constructed.

The type specimen of LAMARCK'S *Geodia gibberosa* in the Museum of the Jardin des Plantes of Paris, the organization of which, through the kindness of Professors MILNE-EDWARDS and VALENCIENNES, I have had an opportunity of thoroughly examining, is unfortunately in so deteriorated a condition in many respects, and especially in regard to the dermal membrane and pores, that I have been induced to select *G. Barretti* from which, to a great extent, to describe the interesting and highly organized structures of this genus; and I have the advantage also in this species of having a portion of a specimen which has never been deteriorated by drying, having been pickled in strong salt and water immediately on being taken from the sea, by my friend Mr. M<sup>c</sup>ANDREW, and in this state it closely resembles a mass of somewhat indurated animal liver.

The skeleton is composed of continuous fasciculi of stout long spicula, which in massive specimens radiate from the base to the outer surface of the sponge, or, if the species be of an elongated form, from the central axis to the circumference, where in either case they terminate at the inner surface of the crustular dermis, intermixing with, and being firmly cemented to, the shafts of the expando-ternate connecting spicula, which are attached to and firmly support the inner surface of the crustular dermis.

The organization of this external crust is exceedingly interesting. The outer surface is composed of a uniform thin pellucid dermal membrane, perforated with innumerable minute pores, variable in their diameter, and apparently possessing the power of opening or closing at the will of the animal. Immediately beneath the dermal membrane there is a stratum of sarcode of variable thickness in different species; and this stratum is permeated by numerous short canals, connecting the external pores with the intermarginal cavities which occupy, at nearly equidistant points, the thick stratum of ovaria forming the inner layer of the crustular dermis. In dried specimens, the positions of the intermarginal cavities are usually indicated on the surface of the sponge by a series of dimples or pits, frequently assuming, by the contraction of the dermal membrane, more or less of a stellated appearance. The proximal extremities of these organs is at the inner surface of the stratum of ovaria, and the distal extremities at the outer surface of the same stratum; and this termination has usually a greater diameter than the proximal end, which is furnished with a stout contractile diaphragm or pyloric valve.

\* Polyparium liberum, carnosum, tuberiforme, intus cavum et vacuum, in sicco durum; externâ superficie undique porosâ. Foramina poris majora in areâ unicâ orbiculari et laterali observata. (LAMARCK, Anim. s. Vert. 2de édit. ii. p. 593.)

The expando-ternate spicula, which are situated at the distal extremities of the radial fasciculi of the skeleton, diverge slightly from each other from their basal extremities, so that their triradiate heads, when firmly cemented to the inner surface of the ovarian stratum, form a strong and regular siliceous network, the points of the radii of each being cemented by keratode to those of its next neighbour; and within the area of each of these meshes of the network there is the proximal end of an intermarginal cavity, the diaphragm of which frequently occupies the greater portion of the area, having a much greater diameter than that of the proximal orifice of the cavity, so that when fully opened its orifice is quite equal to that of the intermarginal cavity. The ovaries vary considerably in size in different species. In the adult and prolific condition they have the form of a strong, thick-shelled, more or less globose ovarium, having a funnel-shaped orifice at the apex, which communicates with the central cavity, which, in the prolific state, is filled with closely-packed minute vesicular bodies, very similar in appearance to those contained in the ovaria of the Spongilladæ, but apparently more minute. In this condition of the ovary its parietes are formed of acutely cuneiform spicula, firmly cemented together by siliceous matter, the united apices forming the inner surface of the ovarium, while the united truncate bases form the external surface. In the early and immature state of the ovaria these truncated bases are not produced, and the young ovary has its outer surface bristling with pointed spicula, which are most acute in the youngest specimens, and become gradually more obtuse as they approach maturity. After the prolific contents of the adult ovary have been liberated, the internal cavity is gradually filled up by the extension inwards of the apices of the cuneiform spicula, until it becomes eventually a solid body; and a similar secretion of siliceous matter is also frequently continued at the outer surface until it often assumes an irregular tuberos and quite abnormal appearance.

The ovarian stratum of the crustular dermis is principally composed of exhausted solid ovaria; but occasionally near the outer surface of the stratum a few prolific ones may be observed, but the greater number of these bodies and of those in an early stage of development are situated amid the deeply-seated portions of the sponge, scattered irregularly over the sarcodous membranes and deeply immersed in the sarcode. In the young state they each appear to be surrounded by a firm stratum of sarcode, which, from its perfectly smooth and circular form, is apparently contained within a proper membrane, but in the fully developed and in the exhausted ovaria this sarcodous envelope is not observable. This description of the organization of the genus will apply equally well to any one of the seven species with which I am acquainted, and also to the nearly allied genus *Pachymatisma*, excepting the mode of the arrangement of the skeleton in the latter.

Both the type specimens of *Geodia* in the Museum at the Jardin des Plantes appear to have had large central cavities; but I have not found similar excavations in other species of the genus, excepting in one instance, a *Geodia* from Port Elliot, Australia; the internal surface in each of the three cases presents precisely the same appearance—a simple irregularly matted surface of spicula and membranes without any thickening of

the tissues, and differing in no respect from the surfaces of any of the smaller internal cavities of the sponge. I am therefore inclined to consider such excavations as abnormal occurrences, which are not entitled to be considered as of either generic or specific value. Part II. Plate XXXII. figs. 2, 3, & 4; and Plate LXXII. fig. 5.

PACHYMATISMA, Bowerbank.

Skeleton composed near the external surface occasionally of short fasciculi of siliceous spicula, disposed in lines at about right angles to the surface of the sponge. Central portion of the sponge unsymmetrical. Dermis crustular, furnished abundantly with closely packed ovaria. Ovaria siliceous, formed of cuneiform spicula, firmly cemented together in lines radiating from the centre of the ovary. Pores furnished with œsophageal tubes, terminating in the distal extremity of each intermarginal cavity. Intermarginal cavities symmetrical, subcylindrical, with a pyloric valve at the proximal end of each.

Since the first publication of my description of the sponge on which this genus is founded in the Synopsis Spongiarum of Dr. JOHNSTON'S 'History of British Sponges,' p. 243, I have found it necessary to base the generic characters of the Spongiadæ on the structural peculiarities of the skeleton and reproductive organs. I have therefore reconstructed the character of the genus in accordance with this rule.

This genus is closely allied to *Geodia* in its organic structure, but the difference in the arrangement of the skeleton readily distinguishes them. The general aspect of the species of each genus is also strikingly distinct. I am acquainted with six species of *Geodia* and three of *Pachymatisma*; and in every case the species may be readily referred to its proper genus even by its general aspect. All the species of either genus have a crustular dermis, and the structures of the ovaria are also alike in each. I have described the anatomical peculiarities of the latter organs so fully in the description of the generic characters of *Geodia* as to render it unnecessary to treat of them here. Plate LXXII. fig. 6.

ECIONEMIA, Bowerbank.

Sponge having a strong axial column or centre of closely packed siliceous spicula disposed in lines parallel to the long axis of the sponge, from which axial column or centre a peripheral system of spicula radiates at about right angles. Distal ends of the radii furnished more or less with ternate connecting spicula, the radii of which are disposed immediately beneath the dermal membrane.

This genus differs from *Dictyocylindrus* in having the axial column composed of a dense mass of parallel spicula instead of a column formed of an open network of spicula; and the peripheral system is also different, inasmuch as it is essentially a portion of the interstitial system of the sponge, and not more especially a defensive system as it appears in *Dictyocylindrus*, in no species of which genus have there ever yet been found ternate spicula at the surface, while in *Ecionemia acervus*, the type species of the genus, they are abundant.

The structure of the peripheral system exhibits a close alliance with the genera *Pachymatisma* and *Tethea*. *Ecionemia* differs from *Geodia* and *Pachymatisma* in the total absence of the siliceous ovaries, and of the crustular dermal coat formed principally of those bodies in the last-named genera. There are also no cylindrical valvular intermarginal cavities, and the ternate apices of the connecting spicula appear always to be applied to the inner surface of the dermal membrane. This arrangement of the tissues therefore forms a natural transition from *Pachymatisma* to *Tethea*, in some species of which genus the ternate spicula are found without the dermal membrane in the porrecto-ternate form, and are adapted to defensive purposes, while in others they occur immediately beneath it as patent-ternate connecting spicula. I have therefore assigned this genus a position between *Pachymatisma* and *Dictyocyclus*. Plate LXXIII. fig. 1.

We have no British species of this genus; the type species, *Ecionemia acervus*, Bowerbank, MS., is in the Museum of the Royal College of Surgeons of London.

*On the Genus* ALCYONCELLUM, Quoy et Gaimard (*Euplectella*, Owen).

Professor OWEN, in his paper on *Euplectella aspergillum*, Owen, communicated to the Zoological Society January 26, 1841, and published in the Transactions of the Zoological Society of London, vol. iii. part 2. p. 203, pl. 13, appears to have fallen into a singular number of errors in the course of his description of this beautiful sponge. He has, in the first place, designated it as belonging to the Alcyonoid family, apparently only because it is cylindrical in form and reticulate in structure, but without the slightest reference to the polyps that must necessarily characterize an Alcyonium; and he proceeds in his description to describe the base of the sponge as its apex and the apex as its base. The author then notices the first specimen of this genus that was made known to us by MM. QUOY and GAIMARD, in the 'Zoologie de l'Astrolabe,' 8vo, 1833, p. 302, planches fol. Zoophytes, pl. 26. fig. 3, but unfortunately mistakes the generic name *Alcyoncellum*, applied to the sponge by the French authors, for *Alcyonellum*; and having mistaken its name, its base, and its apex, he proceeds to reason on its generic characters thus:—"If the basal aperture of the cone were open, the resemblance to some of the known reticulate Alcyonoid sponges would be very close, especially to that called *Alcyonellum gelatinosum* by M. DE BLAINVILLE, 'Manuel d'Actinologie,' 8vo, 1834, p. 529 (*Alcyonellum speciosum*, Quoy et Gaimard): its closure by the reticulate convex frilled cap, in the present instance, establishes the generic distinction; and in the exquisite beauty and regularity of the texture of the walls of the cone, the species surpasses any of the allied productions that I have yet seen or found described. I propose, therefore, to name it *Euplectella aspergillum*." In note 5 appended to this paper, Professor OWEN also says, "If the recognition of the generic or specific identity of the specimen here figured be impracticable by reason of its mutilated condition, the generic name applied to it cannot be adopted while the Lamarckian genus of freshwater polyps, *Alcyonella*, is retained in Zoology." Now as it is manifest that the reasoning of

Professor OWEN in favour of his proposed genus *Euplectella* is based, not upon one only, but upon a series of errors; and as he has not attempted to characterize his own genus, while that of *Alcyoncellum*, Quoy et Gaimard, is regularly described in the 'Histoire Naturelle des Animaux sans Vertèbres' by LAMARCK, 2nd edit. vol. ii. p. 589, printed in 1836, it is evident that the generic name of the French authors must take precedence of that proposed by Professor OWEN.

The following is the generic description of MM. QUOY et GAIMARD:—

“Genre *ALCYONCELLE* (*Alcyoncellum*).

Spongiaire lamelleux, dont la charpente est formée de filets très déliés, accolés les uns aux autres et entre-croisés de manière à former des mailles nombreuses, arrondies, assez régulières, et semblables à celles d'une dentelle.”

In this generic description the material of which the sponge is formed is not in the slightest degree indicated, and the description of its structural peculiarities is so general that it will apply equally well to almost every known fistulose sponge. I have therefore thought it necessary to arrange the sponges of this genus with their congeners in material and mode of construction, and to reconstruct the generic characters so as to endeavour to limit the genus within definite bounds. I propose therefore to substitute the following characters for those of the French authors.

*ALCYONCELLUM*, Quoy et Gaimard.

*Euplectella*, Owen.

Sponge fistulate; fistula single, elongate, without a massive base. Skeleton: primary fasciculi radiating from the base in parallel straight or slightly spiral lines; secondary fasciculi at right angles to the primary ones. Oscula congregated, with or without a marginal boundary to their area.

The congregation of the oscula in *Alcyoncellum corbicula* and *A. aspergillum* is not a character peculiar to those sponges. A similar mode of arrangement exists in several species of *Geodia*. In *G. gibberosa*, in the Museum of the Jardin des Plantes at Paris, they are congregated in an area with a well-defined boundary, and in specimens of *G. Barretti* in my possession they are situated in deep depressions or cavities on the surface of the sponges; and these cavities or areas are not uniform in either shape or size; so we may infer that the presence in some species of *Alcyoncellum* of a well-defined marginal boundary to the oscular area, and its absence in other species, amounts to a specific difference rather than to a generic distinction; but in either case the oscula are congregated at the distal extremity of the sponge, and the areas of its parietes are the inhalant portions of the animal. The inhalation and exhalation of water is precisely on the same principle as that which obtains in *Grantia ciliata*; the whole of the parietes are appropriated to inhalation, the incurrent streams are passed through the interstitial cavities and discharged into a common cloaca, and the effete stream ejected at the distal

extremity of the sponge,—the essential difference being that in *Grantia* the distal end of the cloaca is open, and in *Alcyoncellum* it is partially closed by a cribriform veil, the orifices of which appear to be the true oscula of the sponge. And this opinion is justified by the structure of the numerous cloacæ in the closely-allied genus *Polymastia*, where we find the orifices through which the incurrent streams are poured into the cloaca permanently open.

All the known species of this genus appear to consist of a single fistulose body, and some of them are apparently of a parasitical habit. *Alcyoncellum aspergillum* especially is furnished with numerous recurvo-quaternate spicula at its base, by which it attaches itself to sponges or other bodies. These prehensile organs do not appear in all the species of the genus; and in one perfect and beautiful specimen in the Museum of the Jardin des Plantes at Paris the base is closed, and is entirely destitute of prehensile spicula. The attachment of the sponge is partly, on one side, in the form of a thick incrustation, and partly, close to the base, by a similar patch of thickened tissue. There is also another striking difference in its structure; and that is, the absence of the raised margin to the oscular area at the apex of the sponge. In other structural characters it agrees exceedingly closely with *A. aspergillum*.

#### POLYMASTIA, Bowerbank.

Skeleton a basal mass; central portion consisting of a plexus of contorted anastomosing fasciculi, resolving themselves near the surface into short straight bundles disposed at nearly right angles to the surface. Oscula congregated, elevated on numerous long fistulæ. Fistulæ composed of numerous parallel fasciculi, radiating from the base to the apex of each in straight or slightly spiral lines. Plate LXXIII. fig. 2.

This genus is closely allied to *Alcyoncellum*, Quoy et Gaimard, the principal difference being that in the latter the sponge always consists of a single fistula, while in the former it is constructed of a basal mass from which numerous fistulæ emanate. The fistular organs in each genus very closely resemble each other in their form and structure. Besides these structural differences, there are others, of a less striking description, that strongly indicate the necessity for generic separation. Thus in *Alcyoncellum corbicula*, in the Museum at Paris, and *Euplectella aspergillum*, Owen, there are an abundance of interstitial spicula of rectangulated sexradiate forms, which are very characteristic of those species, while the British species of *Polymastia* with which we are acquainted appear to be totally destitute of these complicated and beautiful forms of spicula. I have therefore thought it desirable, notwithstanding the close agreement that exists in the structure of their fistulæ, that a generic distinction should be established between them.

*Halichondria mammillaris*, Johnston, is the best type of the genus *Polymastia*. The whole of the parietes of these elongated fistulæ are inhalant. In some specimens of *P. mammillaris* dredged in Vigo Bay by my friend Mr. M<sup>c</sup>ANDREW, the open pores are exceedingly numerous, and the exhalant organs are as distinctly shown to be confined to the distal extremities of the fistulæ.

## HALYPHYSEMA, Bowerbank.

Sponge consisting of a hollow basal mass from which emanates a single cloacal fistula.

Skeleton: spicula of the base disposed irregularly; spicula of the fistula disposed principally in lines parallel to the long axis of the sponge, without fasciculation.

In its form and habit the type of this genus closely resembles *Polymastia brevis*; but the total absence of fasciculi in its construction at once marks it as a distinct genus, although a closely allied one. The type species, *H. Tumanowiczii*, is remarkable as being the smallest known British sponge; it rarely exceeds a line in height. The base of the sponge resembles in form the half of an orange cut at right angles to its axis; and the fistular cloaca is usually dilated at its distal extremity. I have been unable to detect either oscula or pores in any of the numerous specimens I have examined; but, from the general accordance in structure with the genera *Alcyoncellum* and *Polymastia*, there is a strong presumption that the oscula will prove to be congregated at the distal extremity of the cloacal fistula, as in those genera. Plate LXXIII. fig. 3.

## CIOCALYPTA, Bowerbank.

Skeleton composed of numerous closed columns, each consisting of a central axis of compact, irregularly elongated reticulated structure, from the surface of which radiate, at about right angles, numerous short simple cylindrical pedicels, or stout fasciculi of closely packed spicula; the distal ends of each pedicel separating and radiating in numerous curved lines, which spread over the inner surface of the dermal membrane, separating and sustaining it at all parts, at a considerable distance from the central axis of the skeleton.

This genus is allied by its structural peculiarities, to a certain extent, to *Dictyocylin-drus*, Bowerbank, *Hyalonema*, Gray, and *Alcyoncellum*, Quoy et Gaimard. The central axial column of the skeleton is composed of elongated stout reticulations of siliceous spicula, closely resembling the corresponding tissues of the axial column of a *Dictyocy-lindrus*; but the space between the surface of the column and the inner surface of the dermis is not filled, as in that genus, by the usual interstitial structures of the sponge, it is completely and widely separated from the dermis in a manner very similar to that of the structure of the greatly elongated cloacal appendage of *Hyalonema mirabilis* as it appears in its present condition in the most perfect specimens in the British Museum and in the collection of Dr. GRAY. There is this difference between the structures of the two genera. The coriaceous dermis surrounding the beautiful spiral axial column of *Hyalonema* is very thick, and is abundantly furnished with projecting oscula; and it does not present any indications of lateral pedicels, either on its inner surface or on the surface of the axial column, while these organs are abundant in *C. penicillus*, and its dermis also is comparatively thin and delicately reticulated.

The dermal portion of the sponge in *C. penicillus*, and the reticulated tissues on its inner surface, closely resemble the corresponding tissues in *Alcyoncellum* in their struc-

ture. The pores, in number, size, and mode of distribution, are very similar to those of *Polymastia robusta*, Bowerbank; but the stratum of these reticulated skeleton-structures is not so thick in proportion, and in *Alcyoncellum* and *Polymastia* there is no central axial column. I could not detect interstitial membranes in any part of the space intervening between the axial column and the dermis in *C. penicillus*; but the skeleton-column is permeated by numerous interstitial canals.

The structure of the short pedicels passing from the axial column to the inner surface of the dermis is different from that of the axis; the spicula composing them are parallel to each other, and they are firmly packed together. The bases of the pedicels arise from the surface and from within the substance of the central column, with which they appear to have no further connexion than that which is necessary to secure them firmly in their respective positions. Their apices present a very beautiful appearance, spreading out towards the inner surface of the dermis in curves diverging at angles of about 45 degrees in every direction over it,—which, when viewed with a microscopic power of about 100 linear, resembles an elaborate and beautifully groined roof of a Gothic crypt. Plate LXXIII. figs. 4 & 5.

#### TETHEA, Lamarck.

The following are the generic characters given by LAMARCK, in his ‘Anim. sans Vert.’ 2nd edit. ii. 384:—

##### “TÉTHIE (*Tethea*).

“Polypier tubéreux, subglobuleux, très fibreux intérieurement; à fibres subfasciculées, divergentes ou rayonnantes de l’intérieur à la circonférence et agglutinées entre elles par un peu de pulpe; à cellules dans un encroûtement cortical quelquefois caduc. Les oscules rarement perceptibles.”

Dr. JOHNSTON’s version of the generic characters differs slightly from LAMARCK’s. It is as follows:—

“Sponge tuberous, suborbicular, solid and compact, invested with a distinct rind or skin, the interior sarcoid loaded with crystalline spicula collected into bundles and radiating from a more compact nucleus to the circumference. Marine.”

It is much easier to find faults in the generic characters of both the authors quoted, than it is to improve them. The extreme simplicity of the structural characters of *Tethea* is a strong temptation to endeavour to multiply them; but in doing so, Dr. JOHNSTON has introduced two—the structure of the dermal portion of the sponges, and the tuberous nature of its surface—which are not common to all the known species. If we consider the word “tuberous” in the usual English acceptation of the word, as a body “full of knobs or swellings,” then very few or perhaps none of the species of *Tethea* would, in their natural condition, exhibit this character; but all of them would be in a greater or less degree subglobular. Dr. JOHNSTON’s description of *Tethea* was founded on the structure of *T. Lynceurium* only; and in this species the “thick rind” is

very distinctly to be seen, but in other species this structure is totally wanting. It therefore ceases to be of value as a generic character, and becomes a specific one only. Under these circumstances I propose the following modification of the previously published generic characters:—

Sponge massive, suborbicular. Skeleton consisting of fasciculi of spicula. Fasciculi radiating from a basal or excentrical point to the surface. Intermarginal cavities unsymmetrical, confluent. Propagation by internal or external gemmulation.

This genus affords us one of the few instances in which we may avail ourselves of external form as a generic character; but even in *Tethea* we approach exceptions to the rule in the depressed form of *T. Collingsii*, Bowerbank, MS., as exhibited in the only perfect specimen of that species which I have seen, and in the still more depressed form of *T. spinularia*, Bowerbank, MS.

Although the skeleton-structures in the species of this genus differ to an exceedingly slight extent, the subsidiary spicula vary exceedingly in the different species. In some, ternate spicula are numerous, and in others they are entirely absent; and stellate forms of spicula occur in many varieties of form.

The sponges of this genus appear to be highly organized. AUDOUIN and MILNE-EDWARDS saw the oscula open and the excurrent streams in action, and I have seen the same myself in a specimen of *T. Lyncurium*. My friend Mr. GEORGE CLIFTON, of Freemantle, Western Australia, in a letter dated 25th January, 1861, writes, "I have sent you several fine specimens of *Tethea*. When these animals are first taken out of the water they are of a brilliant orange-colour, and commence squirting water from the oscula situated on the centre of the upper surface; they also contract considerably, but on being replaced in their native element they regain their natural size and reabsorb water."

The mode of propagation varies in different species. In *T. cranium* and *T. similimus*, Bowerbank, MS., it is by internal gemmulation, in *T. Lyncurium* by external gemmulation; and in some other species the mode is not apparent. Plate LXXIII. fig. 6, and Part II. Plate XXIX. fig. 12.

#### HALICNEMIA, Bowerbank.

Skeleton formed of a single superior stratum of spicula radiating from the centre to the circumference of the sponge at about its middle, and of an inferior stratum of spicula distributed without order.

The nearest alliance to this genus appears to be *Tethea*, in which the skeleton is formed of numerous fasciculi of spicula radiating from the centre to all parts of a spherical or elliptical mass; while in *Halicnemia* the radiating fasciculi are confined to a common plane, beneath which there is a second stratum of spicula, which fills the space beneath the radial stratum and the lower surface of the sponge, but without being disposed in order, and the spicula of the inferior stratum differ materially in form and proportions from those of the superior one.

In the only two specimens of this genus that I have seen, there is a small pebble imbedded in the centre of each sponge, from the surface of which the basal fasciculi of the radial series emanate; but although this appears to be the established habit of this species, it is advisable not to consider it as a generic character, although it may eventually prove to be that the pebble is as much a portion of the skeleton of the animal as the grains of extraneous matter which are taken up by and become imbedded in the keratose fibres of the genus *Dysidea*. Plate LXXIV. figs. 4 & 5.

Dictyocylindrus, Bowerbank.

Skeleton without fibre, composed of a loosely compacted columnar axis of spicula, disposed principally in the direction of the line of the axial column, from which a peripheral system of long single or fasciculated defensive spicula radiate at right angles to the axial column.

*Halichondria hispida*, Johnston, and *Spongia stuposa*, var. *damicornis*, Montagu, are excellent types of the peculiar mode of arrangement of the spicula which characterizes this genus. The skeleton consists of a central column of large elongate spicula, disposed principally in the line of the axis of the sponge and at a slight angle to it, approaching in form an irregular cylinder of network of elongated meshes, rarely exhibiting an appearance of horny fibre, but formed for the most part of spicula cemented together near their terminations. Towards the base of the sponge the horny substance surrounding the spicula is sometimes so thick as to simulate a proper horny fibre; but if it be carefully traced, it will always be found to be dependent on the spicula: where their course is abruptly terminated the horny structure also terminates, whereas in true horny fibrous structures which contain spicula the course of the fibre is continuous and uniform whether the spicula be present or deficient, and in the newly produced fibre the latter is generally the case.

The structure of the skeleton in this genus differs from that of *Halichondria oculata*, Johnston, or *Chalina oculata*, Bowerbank, in the regularly elongate disposition of the spicula of the skeleton; and the spicula are necessarily very much larger and longer than those included in the close fibrous network of *H. oculata*; and it is still further removed from the horny fibrous structure of *Halichondria cervicornis*, Johnston, Hist. Brit. Sponges, pl. 4. The axial column of this genus differs strikingly from that of the strong closely packed axis of *Ecionemia*; and the peripheral system of spicula are never furnished with ternate connecting spicula. All the species of this genus I have hitherto seen are more or less ramous in form. Part II. Plate XXIX. fig. 11; and Plate LXXIII fig. 7.

Phakellia, Bowerbank.

Skeleton composed of a multitude of primary cylindrical axes, radiating from a common base and ramifying continuously, from which emanate at about right angles to the axes a secondary series of ramuli, which ramify continuously as they progress towards the surface, but never appear to anastomose.

I know of no other species, either British or foreign, that possesses the peculiar conformation that distinguishes the sponge that is the type of this genus. The primary cylindrical axes very closely resemble those of *Dictyocylindrus*; but in that genus the spicula radiating from the axes are separate and distinct, each having its proximal end based on the primary cylinders of the skeleton, and its distal one reaching nearly to, or passing through, the dermal membrane of the sponge; or if they be fasciculated, the fasciculi are simply plumose, and in no case with which I am acquainted at all ramulose. In *Phakellia* the secondary skeleton is formed of distinct slender branches, each composed of numerous spicula ramifying continuously, and each ramulus increases in size and the number of its spicula as it approaches the surface of the sponge. Single spicula are frequently projected from the ramuli in an ascending direction at an angle of a few degrees, and at their distal terminations at the surface of the sponge; the whole of the terminal spicula radiate more or less at angles from their axial line, and, passing through the dermal membrane, form the external defences of the sponge. Although constantly ramifying and freely intermingling, I have never detected them anastomosing. The term *Phakellia* is applicable to both the primary and secondary ramifications of the skeleton. The type of this genus is *Halichondria ventilabrum*, Johnston. I have not yet met with an exotic species of the genus. Plate LXXIV. fig. 1.

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The genera *Microciona*, *Hymenaphia*, and *Hymedesmia* form a group essentially different in structural character from the other genera of the Spongiadæ; but they are closely allied to each other by the peculiar characters of their basal membranes, in conjunction with the other parts of the skeleton. From the nature of their structures, the species generally assume a thin coating-form and are often very minute.

In most of the genera of Spongiadæ the basal membrane of the sponge ceases to be of marked importance after the earliest stages of its development, but in these genera it continues throughout the whole existence of the sponge to form an important part of its skeleton-structure. It is a common base whence spring the whole of the other component parts of the skeleton; and its importance is further indicated by its also being in some species the common base of the internal as well as the external defensive spicula of the sponges in which those organs occur.

#### MICROCIONA, Bowerbank.

Skeleton a common basal membrane, whence spring at or about right angles to its plane numerous separate columns of spicula intermixed with keratode, furnished externally with spicula which radiate from the columns at various angles towards the dermal surface of the sponge.

The skeleton of the type of this genus, *M. atrosanguinea*, is different from that of any other genus of sponges that I have hitherto seen. It consists of numerous nearly equidistant, short, straight separate columns of spicula and keratode, from all parts of

the sides of which spring stout, long, curved, fusiformi-attenuato-subspinulate spicula, the convex side of each spiculum being outward; and each column terminates with five or six of these spicula disposed in the same manner and at the same angle to the axial line of the column, that is, from about twenty to forty-five degrees. The proportions of the skeleton-columns vary in different species. In *M. atosanguinea* they are short, stout, and exceedingly well defined. In *M. ambigua* they are short and indistinctly produced, and in *M. carnosa* they are long, slender, flexuous, and frequently branched; but however they may vary in their proportions in different species, their normal character, both as regards structure and position in the sponge, is always preserved. Plate LXXIV. fig. 2, and Part II. Plate XXX. figs. 1 & 2.

Genus HYMERAPHIA, Bowerbank.

Skeleton a single basal membrane, whence spring numerous large separate spicula, which pass through the entire thickness of the sarcodous stratum, to or beyond the dermal surface of the sponge.

This genus is nearly allied to *Microciona*, but is more simple in its structure, as, in place of the columns of the skeleton compounded of keratode and spicula cemented together and emanating from a common basal membrane as in the latter genus, we find single spicula only, devoid of keratode and based on a common membrane, whence they pass through the entire substance of the sponge; and in all the species at present known they penetrate the dermal membrane and project beyond its surface to a considerable extent, thus combining the two offices of skeleton and external defensive spicula. These organs are therefore, as compared with the skeleton-spicula of other members of the Spongiadæ, and to the entire mass of the sponges to which they belong, of exceedingly robust proportions, their length being frequently twice that of the entire thickness of the sponge.

These peculiarities of structure indicate a common habit of extreme thinness in the species; and such is in reality the condition of those with which we are acquainted. Part II. Plate XXX. fig. 3.

HYMEDESMIA, Bowerbank.

Skeleton a common basal membrane sustaining a thin stratum of disjoined fasciculi of spicula.

The species on which this genus is founded very closely resembles in habit and general appearance those of the genera *Microciona* and *Hymeraphia*, and in regard to the special offices of the basal membrane it assimilates with them completely. But it differs from them inasmuch as the spicular portions of the skeleton do not emanate immediately from the basal membrane, but are recumbent on it in the form of disjoined fasciculi of spicula. But although different from them in this important respect, the close alliance with them is indicated by the common habit of the possession by the basal membrane of the whole, or nearly so, of the defensive spicula of the sponge, indicating the common property of extreme thinness of structure which exists in these genera.

The free condition of the fasciculi of the skeleton connects this genus in some degree with the Halichondroid genera of sponges, but there are none of the species of those genera in which the fasciculi of the skeleton are separate from each other. The nearest allied genus in that direction appears to be *Hymeniacion*. Plate LXXIV. fig. 3, and Part II. Plate XXXI. fig. 8.

Suborder II. Spiculo-membranous skeletons. Composed of interstitial membranes having the skeleton-spicula irregularly dispersed on their surfaces.

The prominent character of this Order is, that the spicula of the sponges composing it do not assume either the radiate, fasciculate, or reticulate structural arrangement, the distribution of the spicula on the interstitial membranes being without any approximation to order.

#### HYMENIACION, Bowerbank.

Skeleton without fibre; spicula without order, imbedded in irregularly disposed membranous structure.

In *Hymeniacion* the spicula are subordinate to the membranous structure, they follow its course and are imbedded without order on its surface. The contrary is the case in *Halichondria*. The network of spicula in that genus, although irregular, is decidedly the predominant structure, and the membranous tissues are secondary to it and exist only as interstitial organs. The larger and stouter of the spicula in *Hymeniacion*, although dispersed amid the slender ones, may be considered as the representatives of the skeleton-spicula, while the slender ones are truly those of the membranes.

In some species the interstitial tissues are constructed diffusely, as in *H. caruncula*, while in other species, as in *H. subereum* (*Halichondria suberea*, Johnston) and a few other closely allied species, they are more than usually compact, so that in the dried state the texture of these sponges is very like that of fine hard cork. From this peculiarity of their appearance in the dried condition, and the exceeding compactness of their structure, I was formerly inclined to believe them to be generically different from the great mass of the species of *Hymeniacion*, and I accordingly inserted them in the list of British sponges, published in the Report of the Dredging Committee in the Reports of the British Association for 1860, under the titles of *Halina suberea*, *H. ficus*, &c.; but a closer examination of their internal structure has convinced me that their only real difference from the other species of *Hymeniacion* is in their greater compactness of skeleton-structure, and I have accordingly removed those species to the genus *Hymeniacion*.

In the greater number of the species of this genus the tension spicula are of the same form as those of the skeleton, and are only to be distinguished from them by their greater degree of tenuity; but in a few of the known species they are different both in size and form.

The mode of propagation in all the species in which I have found the reproductive organs appears to be by internal gemmulation. In *H. carnosum* and several other species

of the genus the gemmules are simple, spherical, aspiculous membranous vesicles, filled with round or oval vesicular molecules. The genus *Halisarca*, Dujardin, was supposed by both that author and Dr. JOHNSTON to be entirely destitute of spicula; but I have, since the publication of the 'History of the British Sponges,' found them in *H. Dujardinii* in abundance. They are so minute and so completely obscured by the surrounding sarcode, that they can rarely be detected in either the living or the dead specimens when examined in water; but if a portion of the sponge be dried on a slip of glass and covered with Canada balsam, they may be detected by transmitted light and a power of 400 linear in considerable numbers, dispersed on the interstitial membranes of the sponge. This genus will therefore merge in that of *Hymeniacidon*, with which it agrees in every structural peculiarity. Plate LXXIV. fig. 6.

Suborder III. Spiculo-reticulate skeletons. Skeletons continuously reticulate in structure, but not fibrous.

*Halichondria.*

*Hyalonema.*

*Isodictya.*

*Spongilla.*

The sponges of this suborder vary in the different genera to a great extent in the mode of the construction of the skeleton, but in all cases the spicula are the dominant material; their terminations overlap each other, and they are cemented together by keratode. The reticulations thus formed sometimes consist of a single series of spicula, at other times they are very numerous and are crowded together in the manner of elongated fasciculi.

The genera *Halichondria* and *Isodictya* are exceedingly rich in species; but the inconvenience attending their discrimination, arising from their number, may be remedied to a great extent hereafter by subdivisions of each genus, based on the characteristic forms of the spicula of their respective skeletons. The structural distinction between *Halichondria* and *Isodictya* is so well marked as to render the recognition of each comparatively certain and easy. The skeletons of the species of the latter genus, generally speaking, are very much more slight and fragile than those of the former one; and the same rule obtains to a great extent as regards the comparative size of their spicula, and in many species of *Isodictya* they are very minute. *Hyalonema* and *Spongilla* are readily to be distinguished by the peculiarities of their structure and localities.

The genus *Halichondria* as constituted by Dr. FLEMING in his 'History of British Animals,' and adopted by Dr. JOHNSTON in his 'History of British Sponges,' contains species which differ exceedingly in their mode of organization. Thus, if we take *H. panicea* of JOHNSTON, which is undoubtedly the "sponge-like crumb of bread" of ELLIS and the older authors, and therefore the proper type of the genus, we find the skeleton destitute of fibre, but composed of an irregular network of spicula cemented together at their apices by keratode. If we examine the well-known branching sponge

so common on all our coasts, *Halichondria oculata* of the same author, we find an abundance of keratose fibre containing spicula deeply imbedded in its substance, but not necessarily uniting at their apices; and the network of the skeleton is not irregular as in the first instance, but on the contrary is more or less symmetrically disposed in all parts of the sponge. If we take *Halichondria suberea* of the same authors, we find neither network of spicula nor a keratose fibrous structure, but apparently an amorphous sarcoid mass containing spicula and membranes, on which the former are dispersed without any order or connexion. As we extend our researches among the other British species of FLEMING'S genus *Halichondria*, other striking and permanent variations in the arrangement of their skeleton-tissues present themselves. Their great differences in structure therefore afford ample grounds for the division of the species comprehended under *Halichondria* as constituted by FLEMING into a series of genera having each for its base a separate type of organization; and as the variations in structural character, some of which are mentioned above, are both numerous and strikingly characteristic, I propose to limit the genus *Halichondria* to those species only which agree in their organization with *H. panicea* of JOHNSTON, and to distribute the remaining species in other genera, the distinctive characters being in all cases based primarily on the different modes of the organization of the skeleton of the animal, and when necessary taking in aid such other organic characters as may be found available for the purpose of accurate discrimination. I therefore propose to limit the genus *Halichondria* to those sponges only that exhibit the following characters.

#### HALICHONDRIA, Fleming.

Skeleton without fibre, composed of an irregular polyserial network of spicula cemented together by keratode.

Type, *Halichondria panicea*, Johnston.

The anatomical structure of the group included under this genus is distinct and unmistakeable. There is no fibre whatever, the skeleton being formed of spicula collected into bundles of a greater or less number, cemented together by keratode, which substance, however, does not extend beyond the space occupied by the respective bundles; and when parts of the reticulated skeleton are formed of single series of spicula only, they are simply cemented together at their points, and the reticulated skeleton thus formed has no definite arrangement. Plate LXXIV. fig. 7, and Part II. Plate XXXII. figs. 1 & 5.

#### HYALONEMA, Gray.

Dr. GRAY has characterized this genus in his descriptions of genera of Axiform Zoophytes, or Barked Corals, as "coral subcylindrical, rather attenuated, and immersed in a fixed sponge. Axis in the form of numerous elongated, slender, filiform, siliceous fibres, extending from end to end of the coral, and slightly twisted together like a rope. Bark fleshy, granular, strengthened with short cylindrical spicula. Polypiferous cells scattered, rather produced, wart-like, with a flat radiated tip." (Proceedings of the

Zoological Society of London for 1857, page 279.) This description applies only to the singular cloacal appendages to the sponge from amidst which it springs, the structure of the body of the animal being evidently considered by the author as an extraneous mass. The basal sponge is undoubtedly a portion of the animal to which the part described by Dr. GRAY belongs, the spicula of the elongated cloacal portion being also abundant in the basal mass of sponge; and the basal mass of the specimen described by Dr. GRAY is identical in its structural character with that of the specimen of *Hyalonema mirabilis* in the Bristol Museum. It becomes necessary therefore to remodel the generic characters so as to embrace the leading distinctive structures of the skeleton of the animal; and I propose the following form of description:—

Skeleton an indefinite network of siliceous spicula, composed of separated elongated fasciculi reposing on continuous membranes, having the middle of the sponge perforated vertically by an extended spiral fasciculus of single, elongated and very large spicula, forming the axial skeleton of a columnar cloacal system.

The construction of the skeleton of the mass of the sponge is intermediate between that of *Halichondria panicea* and *Hymeniacidon caruncula*, the respective types of those genera. The network of fasciculated spicula appears never to be definite and continuous as in the former, nor are the skeleton-spicula in a dispersed condition on the continuous membranes as in the latter, but are gathered into elongated fasciculi which cross each other in the same plane in every imaginable direction, but without ever appearing to anastomose. The fasciculi vary exceedingly in the number of spicula of which their diameter is formed, sometimes consisting of two or three spicula only, and at other times of more than it is possible to count. They often divide, the branches passing in different directions, but they never reunite or anastomose with other fasciculi. A portion of this network of spicula is represented by figure 3, Plate XXXI. Part II. The columnar axis of the cloacal system consists of one large spiral fasciculus of spicula, each of which extends from the base or very near that part of the sponge, to near or quite to the apex of the column, the direction of the spiral being from right to left.

There is a close approximate alliance to this form of the cloacal appendage of *Hyalonema* in the corresponding organs of the British genus *Ciocalypta*, Bowerbank, MS.

ISODICTYA, Bowerbank.

*Spongia*, Montagu.

*Halichondria*, Fleming.

*Halichondria*, Johnston.

Skeleton without fibre; composed of a symmetrical network of spicula; the primary lines of the skeleton passing from the base or centre to the surface, and the secondary lines disposed at about right angles to the primary ones. Propagation by internal, membranaceous, aspiculous gemmules.

This genus, in the structure and arrangement of its skeleton, is intermediate between

*Halichondria* and *Chalina*, as defined in the present work. Like the former, the spicula of the network composing the skeleton are merely cemented together, not enclosed within a regular horny fibre; but the disposition of the network is not entirely irregular, but like that of the latter genus, more or less composed of a primary series of lines radiating from the axis or base of the sponge, and of secondary series connecting the primary ones at about right angles to them—in fact simulating very closely the arrangement of the skeleton of *Chalina oculata*, but without the keratose fibre surrounding the spicula of the skeleton in that sponge.

In some of the species of this genus the symmetrical arrangement of the lines of the skeleton is distinct only near the surface of the sponge, while in the more deeply seated parts the irregular character of a *Halichondria* is simulated. In determining the species of this genus, the sponge requires to be carefully examined by sections at right angles to the surface, where the distinctive character rarely fails to be readily detected. On the contrary, in *Halichondria panicea*, the type of that genus, I have never succeeded in finding such a linear arrangement of the skeleton as marks that of *Isodictya*. In a hasty examination a single linear series of spicula will therefore often prove an excellent guide to the discrimination of this genus.

In most of the species with which I am acquainted there is a generally prevailing character of fragility—the primary lines being composed of very few spicula, while the secondary ones are most frequently unispicular. Most of the species are thin-coating or encrusting sponges, and rarely appear to rise in tuberos masses, as the numerous species of *Halichondria* are in the habit of doing.

*Isodictya infundibuliformis* is perhaps the most perfect type of the genus, as in it we have the primary and secondary lines of the skeleton distinctly separated by the difference in the form of their spicula. In some species of the genus, as in *I. simulo*, the cementing keratode of the skeleton is so abundant in some parts as to cause it to simulate very closely the structure of a *Chalina*; but the irregularity and compressed form of this pseudo-fibre is readily to be distinguished from true keratose fibre by a careful observer. In other species, as in *I. mammeata*, the sarcode surrounding the skeleton is so abundant as to cause it to simulate a delicate form of *Chalina*; but on immersion in Canada balsam the fibre-like form disappears, the sarcode contracting into a mere granulated coating, and the skeleton assumes the normal appearance of *Isodictya*. Plate LXXIV. fig. 8.

SPONGILLA, Linnæus, Lamarck, and Johnston.

*Halichondria*, Fleming.

The structural peculiarities of the skeleton of *Spongilla* are the same as those of *Isodictya*; and if there had not existed a striking distinctive difference in their reproductive organs, the two genera must have been united. Under these circumstances I propose the following as the characters of the genus *Spongilla*.

Skeleton without fibre, composed of a symmetrical network of spicula; the primary

lines of the skeleton passing from the base or centre to the surface, and the secondary lines disposed at about right angles to the primary ones. Reproductive organs ovaries, coriaceous and abundantly spiculous.

All the species are inhabitants of fresh water. The best type of the genus is *Spongilla fluviatilis*, Johnston. As an illustration of the form of the skeleton in this genus, see the figure of that of *Isodictya Normani*, Plate LXXIV. fig. 8.

Suborder IV. Spiculo-fibrous skeletons. Regularly fibrous. Fibres filled with spicula.

*Desmacidon*.

*Raphyrus*.

The spiculo-fibrous skeletons differ from the fibro-spicular ones in this respect. In the first the form and proportions of the fibre are dependent on the greater or the less development of spicula, and the keratode serves only as a cementing and coating material. In the latter the keratode is the primary agent in the formation of the fibre, and the spicula the secondary or auxiliary agent only.

DESMACIDON, Bowerbank.

*Halichondria*, Johnston.

Skeleton fibrous, irregularly reticulated. Fibres composed entirely of spicula arranged in accordance with the axis of the fibre, cemented together and thinly coated with keratode.

The structure of the skeleton-fibre in this genus readily distinguishes it from all others. The form and size of the tissue is entirely dependent on the greater or less quantity of spicula present, the keratode serving only as a cementing and coating material. *Halichondria ægagropila* and *H. fruticosa*, Johnston, are the only two British species of the genus known. Part II. Plate XXVII. fig. 10.

RAPHYRUS, Bowerbank.

Skeleton fibrous, but not horny. Fibre composed of a dense mass of siliceous spicula mixed together without order.

The structure of this genus is singular. The fibre in the only species with which I am acquainted, *Raphyrus Griffithsii*, is comparatively very coarse, frequently attaining the size of a line in diameter near the anastomosing parts, or expanding into a broad plate-like form. The spicula composing it are closely thrown together without any approach to the longitudinal disposition which prevails in the skeleton of *Desmacidon*. The same absence of definite arrangement obtains in the interstitial membranes, which have precisely the mode of structure which characterizes the genus *Hymeniacidon*, which has "spicula without order, imbedded in irregularly disposed membranous structure." Part II. Plate XXVII. fig. 11.

Suborder V. Compound reticulate skeletons, having the primary reticulations fibrospiculate, and the interstices filled with a secondary spiculo-reticulate skeleton.

*Diplodemia.*

This genus forms a connecting structural link between the orders Silicea and Keratosa. The structure of the keratose fibre would indicate its place to be in the third suborder of the latter; but the presence of the Halichondroid secondary skeleton in such force, in conjunction with the irregular spiculated structure of the keratose fibrous primary skeleton, has induced me to place it among the Silicea. For more minute information regarding its structural peculiarities, I must refer my readers to the following description of the generic characters of *Diplodemia*.

DIPLODEMIA, Bowerbank.

Skeleton fibrous; fibres keratose, heterospiculous; combined with a secondary skeleton of irregular network of spicula; rete unispiculate, rarely bispiculate. Ovaries membranous and spiculous.

The fibres in the skeleton of the only known species in this genus are very remarkable. They are smooth and cylindrical, having an axial line of, generally speaking, single spicula united at their points, running throughout the whole length of the fibre. But when it is of more than ordinary diameter, there are frequently other spicula at intervals imbedded in the fibre, parallel to the axial series. Throughout the whole length of the fibres, at short intervals, there are similar spicula to the axial ones, imbedded at right angles to the axis of the fibre, frequently projecting from the surface for half, or more than half, their length. Some of these projecting spicula originate small lateral branches of the keratose skeleton; but by far the greater portion of them are the connecting points of the keratose fibres and the reticulo-spiculate secondary skeleton, the former being thus completely imbedded amidst the latter.

The structure of the ovaria in this genus is also peculiar to it. The wall is very thin, and appears to consist of a single membrane profusely furnished with spicula which cross each other in every direction, and occasionally appear to assume a somewhat fasciculated arrangement. They are not uniform in shape, some being regularly oval, while others are more or less ovoid.

But one species of this singular genus is known, *D. vesicula*, Bowerbank, MS., from deep water at Shetland. Plate LXXIII. fig. 8, and Part II. Plate XXXIV. fig. 1.

Suborder VI. Solid siliceo-fibrous skeletons. Skeletons reticulate. Fibres composed of concentric layers of solid silex, without a central canal. Reticulations unsymmetrical.

*Dactylocalyx*, Stutchbury (*Iphiteon*, French Museum).

The structure and mode of growth in this suborder of siliceo-fibrous sponges appear

to be precisely the same as that of the kerato-fibrous sponges of the first suborder of Order III. Keratosa.

*Dactylocalyx pumicea*, Stutchbury, was described in the Proceedings of the Zoological Society, part ix. 1841, p. 86, October 26, 1841. The author describes it thus: "Sponge fixed, siliceous; incurrent canals uniform in size; excurrent canals large, forming deep sinuosities on the outer surface, radiating from the root to the outer circumference."

The sponge was received by the Bristol Museum from Dr. CUTTING of Barbadoes.

The genus *Dactylocalyx* was established by Mr. STUTCHBURY to designate this fine siliceo-fibrous sponge. Half of the type specimen is in the Museum at Bristol, and the remaining portion in the possession of Dr. J. E. GRAY of the British Museum. Although the sponge was designated *Dactylocalyx pumicea*, no generic characters were given. I propose therefore to characterize it as follows:—

#### DACTYLOCALYX.

Skeleton siliceo-fibrous. Fibres solid, cylindrical. Reticulations unsymmetrical. Part II. Plate XXXIV. fig. 17.

Suborder VII. Canaliculated siliceo-fibrous skeletons. Skeletons reticulate, symmetrical. Fibres composed of concentric layers of solid silex, with a continuous central canal.

Type, *Farrea occa*, Bowerbank, MS.

I have seen in the organic remains from deep-sea soundings several varieties of fragments of siliceous fibres with simple central canals, having every appearance of being from unknown species of siliceo-fibrous sponges; but the only satisfactory specimen of this genus of sponges is the one at the base of Dr. ARTHUR FARRE's specimen of *Euplectella cucumer*, Owen, described in the Transactions of the Linnean Society of London, vol. xxii. p. 117, plate 21.

The fibres in *Farrea occa* are rather coarse, abundantly tuberculated, and the mode of reticulation is rectangular. Their construction is exactly like those of *Verongia*, the type of the fourth suborder of the third order, Keratosa. Part II. Plate XXVII. fig. 11.

#### Order III. KERATOSA.

Suborder I. Solid non-spiculate kerato-fibrous skeletons.

The greater number of the sponges of commerce belong to this suborder. How many species are comprised under the designation of "the sponges of commerce" it is very difficult to decide, as we rarely obtain them in their natural condition; but it is certain, from their well-washed skeletons, that their number is considerable, and that at least two distinct genera occur among them. If we assume that the well-known cup-shaped sponge, usually sold as the best Turkey sponge, is the one entitled to the designation of

*Spongia officinalis*, we shall then have the type of the first suborder of the order Keratosa, distinguished by the above characters. There are two genera belonging to this suborder; the first of these is *Spongia*, Linnæus. Its character is as follows:—

SPONGIA, Linneus.

Skeleton kerato-fibrous. Fibres solid, cylindrical, aspiculous. Rete unsymmetrical.

Type, *Spongia officinalis*, Linnæus.

The number of species of *Spongia* appear to be very considerable; and in all of them the irregular meandering character of the skeleton-fibre readily serves to distinguish them. Plate LXXIV. fig. 9, and Part II. Plate XXVII. fig. 7.

The second genus is founded on the specimen described by SOWERBY in the 'British Miscellany,' p. 87, plate 48, and named by him *Spongia pulchella*. I fortunately have this specimen; and on carefully examining it I find it to possess all the characters of the genus *Spongia*, excepting that the reticulations of the skeleton are very symmetrical; and this is so important a structural difference that I have thought it advisable to constitute it the type of a new genus, the characters of which are as follows:—

SPONGIONELLA, Bowerbank.

*Spongia*, Sowerby and Johnston.

Skeleton kerato-fibrous. Fibres solid, cylindrical, aspiculous. Rete symmetrical; primary fibres radiating from the base to the apex. Secondary fibres disposed at nearly right angles to the primary ones. Plate LXXIV. fig. 10.

Type, *Spongia pulchella*, Sowerby.

Suborder II. Solid, semispiculate, kerato-fibrous skeletons.

The sponges of this suborder closely resemble in general appearance those of the genus *Spongia*, but they differ very considerably in the structural characters of their skeletons, which consist of a somewhat irregular radiation of primary fibres from the base towards the apex of the sponge, with an unsymmetrical series of secondary fibres emanating from and connecting together the series of primary ones.

The primary fibres are compressed and broad in their form, frequently three or four times the width of the diameter of the surrounding cylindrical secondary ones. But their most striking character is their possessing a considerable number of siliceous spicula, which are irregularly imbedded in their centres; sometimes the series of spicula within the fibre consists of but one or two beside each other, and at other times they are numerous and very irregularly disposed. This central series of spicula appears to exist only in the primary fibres; and I have never been able to detect the slightest indi-

cation of their presence in any of the secondary series. I first described these structural peculiarities in a paper read before the Microscopical Society of London, January 27, 1841; and it is published in vol. i. p. 32, plate 3, of their 'Transactions.'

I have met with numerous instances of the occurrence of this structural arrangement of the skeleton in sponges from Australia and the Mediterranean; but their well-washed condition has left them with but very few capabilities for specific distinction.

I propose to adopt DE BLAINVILLE'S name *Halispongia* to designate this genus, the characters of which are as follows:—

#### HALISPONGIA, De Blainville.

Skeleton kerato-fibrous. Fibres solid; primary fibres compressed, containing an irregularly disposed series of spicula. Secondary series of fibres unsymmetrical, cylindrical, without spicula. Plate LXXIV. fig. 11.

Suborder III. Solid, entirely spiculate, kerato-fibrous skeletons.

#### CHALINA, Grant.

Skeleton fibrous. Fibres keratose, solid, cylindrical, and interspiculate. Rete symmetrical; primary lines radiating from the basal or axial parts of the sponge to the distal portions. Secondary lines of fibre at about right angles to the primary ones.

The type of this genus, *Halichondria oculata*, Johnston, differs so materially in the structure of its skeleton from that of the type of *Halichondria*, *H. panicea*, Johnston, that it becomes necessary that a distinct genus should be established to receive it and other closely allied British species. The skeleton consists of a solid cylindrical keratose fibre, enclosing a single or compound series of spicula, imbedded at or near its centre, and disposed in lines parallel to its axis, thus forming a structural group intermediate between that of *Halichondria panicea* and *Spongia officinalis*.

In the sponges of this genus the spicula are decidedly subservient to the fibre, which is always cylindrical, and generally very uniform in its diameter throughout the whole of a section made at right angles to its surface; while in the nearly allied genus, *Isodictya*, the reverse is the case, the spicula being the essential basis of the skeleton, while the surrounding keratode, although often abundant, is still only the subservient cementing medium of the skeleton, and never assumes the decidedly cylindrical form of that of the fibre of *Chalina*.

In the Edinburgh Encyclopædia, vol. xviii. p. 844, Dr. GRANT proposed the name *Halina* to represent those species which were designated *Halichondria* by Dr. FLEMING, and subsequently by Dr. JOHNSTON in his 'History of British Sponges;' but as I have already proposed to restrict the term *Halichondria* to those species which agree in structure with the original type of that genus (*H. panicea*, Johnston), it becomes necessary to select other names to represent the sponges which differ essentially in their structure from that type, and I therefore propose to adopt Dr. GRANT'S genus *Chalina*, designated

in his 'Tabular View of the Animal Kingdom,' published in 1861, to represent that portion of them which agree in structure with the well-known species described in the 'History of the British Sponges' as *Halichondria oculata*. Part II. Plate XXVII. fig. 8.

#### Suborder IV. Simple fistulo-kerato-fibrous skeletons.

The type of this suborder is LAMARCK'S *Spongia fistulosa*. The anatomical structure and the general habits of the sponges of this description are so widely different from the true Spongiæ, that I was induced to establish them as a separate genus, and I accordingly designated and described them as such in the Annals and Magazine of Natural History for December 1845, vol. xvi. p. 400, plate 13. fig. 7. It is unnecessary to enter here into a detailed account of these tissues, as I have described the peculiarities of the structure of the simple fistulo-keratose fibrous skeletons at length in the second part of this paper at p. 755, and figured the tissue in Plate XXVII. fig. 12.

The genus may be characterized as follows:—

VERONGIA, Bowerbank.

*Spongia*, Lamarck.

Skeleton kerato-fibrous. Fibres cylindrical, continuously fistulose, aspiculous. Rete unsymmetrical.

#### Suborder V. Compound fistulo-fibrous skeletons.

This suborder is founded on the peculiarities in the structure of the skeleton-fibre of a sponge described by me in the Annals and Magazine of Natural History for December 1845, vol. xvi. p. 405, plate 13. figs. 1 & 2, and also in the second part of this paper, p. 756, and figured in Plate XXVII. figs. 13 & 14.

The genus *Auliskia* is the only one in which compound fistulo-keratose fibres have been found, and it may be thus characterized:—

AULISKIA, Bowerbank.

Skeleton kerato-fibrous. Fibres aspiculous, cylindrical, continuously fistulose; primary fistulæ having minute cæcoid canals radiating from them in every direction. Rete unsymmetrical.

#### Suborder VI. Regular semi-areno-fibrous skeletons.

The sponges of this suborder have the faculty of appropriating extraneous matter, such as grains of sand, or the spicula of other sponges, which become imbedded in the centre of the cylindrical fibres of their skeletons. The fibres in these cases are regular and cylindrical, and the space between their surfaces and the central line of extraneous matter is frequently one-fourth or one-third of their own diameter. The central axis of extraneous matter usually consists of a series of single grains, but occasionally we find

two or three compressed together. In some genera belonging to this suborder the arenation of the fibres is confined to the primary or radial ones, and the fibres of the secondary system are destitute of extraneous matters. In other genera they occur occasionally in the secondary system as well as in the primary one. In *Stematumenia* the primary fibres are frequently somewhat compressed, and are abundantly arenated. The smaller or secondary series of fibres are usually cylindrical, and most frequently without either grains of sand or spicula. Several of the common Bahama sponges of commerce belong to this suborder; but the best type is the genus *Stematumenia*, described by me in the Annals and Magazine of Natural History for December 1845, vol. xvi. p. 406, plate 14. figs. 1 & 2. The genus may be characterized as follows:—

STEMATUMENIA, Bowerbank.

**Skeleton.** Primary fibres solid, more or less compressed, containing a central axial line of spicula and grains of extraneous matters. Interstitial structures abundantly fibromembranous. Part II. Plate XXVII. figs. 3 & 5, and Plate XXVIII. figs. 1 & 2.

Suborder VII. Irregular and entirely areno-fibrous skeletons.

Types, *Dysidea fragilis*, Johnston.

*Dysidea Kirkii*, Bowerbank.

The peculiarity of this suborder is, that the fibre of the skeleton is a full and complete but elongate aggregation of particles of sand, each separately coated by keratode, forming a series of stout anastomosing fibres, consisting of innumerable extraneous molecules encased by a thin coat of keratode.

In *Dysidea Kirkii*, an Australian species, both the primary and secondary fibres of the skeleton are comparatively large, frequently exceeding half a line in diameter. In our British species, *Dysidea fragilis*, Johnston, the primary fibres are often as abundantly arenated as those of the Australian species, while the secondary ones are only partially filled with extraneous matter, and in this condition they are frequently more or less tubular. Part II. Plate XXVIII. figs. 3, 4 & 5.

The structure and peculiarities of the above-named two species are described in detail in vol. i. p. 63, plate 6 of the Transactions of the Microscopical Society of London.

*On the Discrimination of the Species of the Spongiadæ.*

One of the reasons why so little progress has been made in our knowledge of the Spongiadæ is, that the generic and specific characters that are visible to the unassisted eye, such as form and colour, are in this class of animals remarkably uncertain and delusive, while all those that are definite and constant require not only a high degree of microscopical power to make them visible, but frequently also a peculiar mode of treatment to render them apparent even beneath the microscope. Thus it is with many

of the finer forms of stellate spicula, which are very characteristic in *Tethea*, *Geodia*, *Spongilla*, and other genera. When we search for them by the dissolution of the tissues in nitric acid, they are so minute that by far the greater part of them, even with the most careful treatment, are washed away; and when the tissues in which they are imbedded are examined in water, they are totally invisible in the sarcode in which they are immersed; and it is only when small portions of such tissues are mounted in Canada balsam that they become distinctly visible *in situ*. The correct classification therefore, as well as the anatomy and physiology, is really a microscopical science; and it is only since we have possessed instruments of high defining and penetrating powers, that we have been properly prepared for the investigation of the structures and the correct determination of the generic and specific characters of these interesting and curiously constructed animals. A careful and patient examination of their component parts is therefore absolutely necessary for the determination of species; and the whole of the structures present should be noted and their peculiarities accurately described.

In the first place we will consider what are the parts of the organization of the Spongiadæ that may be used for the purposes of specific distinction; and secondly, endeavour to form an estimate of their relative values.

The parts of the sponge to be thus employed are as follows:—1. The Spicula. 2. The Oscula. 3. The Pores. 4. The Dermal Membrane. 5. The Skeleton. 6. The Interstitial Membranes. 7. The Intermarginal Cavities. 8. The Interstitial Canals and Cavities. 9. The Cloacal Cavities. 10. The Sarcodæ. 11. The Ovaria and Gemmules.

### 1. *The Spicula.*

The spicula in the descriptions of the Spongiadæ are of about the same relative value that the leaves of plants are in botanical descriptions. I have shown in the first part of this paper, published in the Philosophical Transactions for 1858, that they are exceedingly various in form in the different species; and even when of the same shape in two different sponges, as represented in fig. 9 *a* & *b*, Plate XXIII. Phil. Trans. 1858, their relative proportions are frequently so distinctly different as to render them almost as valuable as if they varied from each other in form. Wherever therefore spicula form a component part of the skeleton, they become a leading character in the discrimination of species. But it is not only those of the skeleton that are thus available, as in different sponges they vary in shape and size in each separate organ belonging to the animal; and in some cases we find as many as five or six distinct descriptions of spicula, each of which affords an invariable and excellent character. Thus, in the descriptions of sponges, it is not only the forms and relative proportions of the skeleton-spicula which have to be taken into consideration, but those also of the dermal and interstitial membranes (the external and internal defensive ones), those of the sarcodæ, and of the ovaries and gemmules. Those of the latter three organs named frequently afford the most determinative characters. Thus in the genus *Spongilla* but one form of spiculum, the acerate, prevails in the skeletons of all the known species; but the minute and

beautiful spicula of the ovaria vary in form and size, in passing from one species to another, in a perfectly unmistakeable manner, so that, if the organs of reproduction be present, which is most frequently the case, the species may be readily recognized from their spicula only. But in other cases, and even in the same genus in the absence of the ovaria, the differences between two nearly allied species are equally well determined by the spicula of the dermal and interstitial membranes. Thus, in our two species of British *Spongilla*, *S. fluviatilis* has no tension spicula different from those of the skeleton, while in *S. lacustris* we find the fusiformi-acerate entirely-spined spiculum, represented in fig. 21, Plate XXIV. Phil. Trans. 1858, in abundance. So likewise in two species of *Tethea*, *T. cranium* from Shetland, and *T. simillima*, Bowerbank, MS., from the Antarctic regions, the only well-determined difference that exists is, that the sarcode of the former is profusely furnished with exceedingly minute sigmoid spicula, while that of the latter is entirely destitute of them. It will therefore be seen that these exceedingly minute organs frequently afford the most valuable and certain means of discriminating species. But although so minute, we must not imagine that it is very difficult to obtain these characteristic evidences; for, as I shall show more at length hereafter, it requires but the dissolution of a small piece of the sponge in hot nitric acid to at once furnish us with a general view of the whole of the spicular contents of the sponge under examination; so that, to one who has become familiarized with the general characteristics of the forms and sizes of the different classes of spicula peculiar to each organ of the sponge, such a preliminary observation at once indicates the nature and especial seat of the principal specific characters of the subject under examination.

In some sponges the relative variation in size of the adult skeleton-spicula is greater than in others; but this variation, although sometimes a substantial character, must not be always assumed to be correct, as in young sponges with simple forms of skeleton it is very difficult to discriminate between the young and only partially developed spicula and the adult ones. Thus in a young specimen of *Spongilla fluviatilis*, I found in the same field of view one spiculum perfectly well proportioned which measured  $\frac{1}{324}$ th of an inch in length and  $\frac{1}{10000}$ th of an inch in diameter, another  $\frac{1}{241}$ st of an inch in length and  $\frac{1}{7500}$ th of an inch in diameter,—the length and diameter of an average-sized spiculum of the species in a fully developed condition being, length  $\frac{1}{75}$ th of an inch, and diameter  $\frac{1}{2000}$ th of an inch.

Abnormal or immature forms must not be mistaken for fully developed and normal ones, as we find in some of the more complicated forms of spicula that the development of form is quite as progressive as that of size, as instanced in figs. 4, 5, 6 & 7, Plate XXIV. Phil. Trans. 1858, which represent the progressive stages of development of the spinulo-recurvo-quaternate form of spiculum, and also in figs. 4, 5, 6, 7 & 8, Plate XXV. Phil. Trans. 1858—where the first four figures represent the progressive development of the dentato-palmate inequianchorate spiculum, and the last an abnormal form, probably arising from arrested development.

## 2. *The Oscula.*

The oscula frequently afford good specific characters. Their peculiarities are, first, those of position; and secondly, those of form. Thus it should always be noted whether they are dispersed or congregated, whether disposed on the exterior surface or on the parietes of internal cloacæ. In form they are either simple orifices, or they assume a tubular shape to a greater or a less degree, and sometimes they are bounded by a slightly elevated marginal ring. All these characters are subject to a considerable amount of variation, which is sometimes dependent on peculiarities of locality, and at others on age or the amount of their development; but a comparison of several specimens of the same species will generally lead the observer to a correct conclusion regarding their normal characters.

In some species these organs are always more or less open; in others, especially littoral ones, they are entirely closed during exposure to the atmosphere, or while in a state of repose, during which condition they are frequently completely inconspicuous.

## 3. *The Pores.*

The pores afford but very few available characters. They are either dispersed or congregated, very rarely in the latter state. They are also either conspicuous or inconspicuous: that is, in the former condition their presence, and the areas within which the groups of them are situated, may be readily detected by the aid of a hand-lens; in the latter case they are perfectly undistinguishable without high microscopic power.

## 4. *The Dermal Membrane.*

The dermal membrane affords many important specific characters. In the greater number of the Spongiadæ it is a simple pellucid membrane, which invests the whole of the mass of the sponge; but in other cases it is of much more complex structure, sometimes furnished abundantly with primitive fibrous tissue, or a network of spicula or kerato-fibrous tissue for its especial support; and in the areas of such network there are frequently tension spicula differing in construction from those of the skeleton, and its interior surface is often supplied with anchorate retentive spicula of various forms. In its sarcodous lining there are occasionally an infinite number of stellate or spherostellate spicula to protect it from the ravages of minute enemies, and its surface is also often penetrated by large or small defensive spicula. Occasionally its external surface is profusely supplied with elongo-stellate defensive spicula. It has also frequently a thick stratum of cellular structure of various colours.

These peculiarities of structure have no generic value. They are essentially specific differences; and it is rarely the case that any two species, even in an extensive genus, are found to agree in the possession of the number, form, or mode of disposition of these peculiarities of the dermal tissues. They form therefore a constant and highly valuable series of characters, and claim the especial attention of the student in either the recognition or description of an unknown species.

### 5. *The Skeleton.*

Although the material, mode of structure, and arrangement of the skeleton is more especially devoted to the formation of the orders and suborders, it still presents us with a sufficient number of minor peculiarities to render it a source of valuable specific characters. Thus, as I have already shown, in treating of the relative value of the spicula for the distinction of species, the difference in their size affords a good character. The closer or more diffuse mode of their arrangement modifies to a great extent the form and size of the areas in spiculo-reticulated skeletons, and their habitually greater or less number in the thread of the reticulations produces a distinctly different aspect in the skeletons of two otherwise closely allied species. The presence or absence of defensive spicula, the mode of armature, and the forms of the defensive and other auxiliary spicula also afford a very extensive and valuable series of specific characters. In the kerato- and siliceo-fibrous sponges there are peculiarities of a similar description, such as the presence of a reticulo-fibrous sheath, as represented in figs. 9 & 10, Plate XXVIII. Part II., or the possession of spines or tubercles of various forms, as represented in the same Plate, figs. 7 & 8, or of extraordinary modifications for prehension, as in the cidarate siliceo-fibrous skeleton, represented also in the same Plate, fig. 12. These and other similar structural peculiarities afford a series of characters which are usually of a permanent and very striking description.

### 6. *The Interstitial Membranes.*

The peculiarities of the interstitial membranes consist principally in the shape and proportions of their tension spicula, or of the forms and varieties of structure, and mode of disposition, of the retentive spicula. The latter class of organs especially present a very extensive series of striking characters that are essentially specific. In the genera *Halichondria*, *Isodictya*, *Hymeniacidon*, and others containing numerous species, often very closely resembling each other in all the principal structural characters, they frequently, from the strongly marked peculiarities in their form and proportions, present most valuable and decisive specific characters. Plate XXVII. figs. 1, 2, 3 & 5.

In *Alcyoncellum* and other genera the interstitial membranes are strengthened and supported by layers of primitive fibrous tissue, arranged in parallel lines; and in *Stemmatumenia* the same fibres abound, but they are not disposed in the same symmetrical manner, and in some sponges cellular structures are present in considerable quantities. These tissues are all more or less valuable as aids in specific distinction.

### 7. *The Intermarginal Cavities.*

The intermarginal cavities in the greater portion of the Spongiadæ are so indefinite in their form as to render but little service in the distinction of species; but in *Geodia*, *Pachymatisma*, and a few other genera their structure is very much more regular, and their form, proportions, and mode of disposition afford good characters. But although of no extensive essential value themselves, their subsidiary ternate spicula present a

great number of strongly marked specific distinctions, arising not only from their varieties of form and proportion, but also from their relative positions in the dermal crusts of those genera where they most abound; and their modes of disposition and connexion with each other are also very characteristic.

#### 8. *The Interstitial Canals and Cavities.*

These organs themselves present very few characters that are of much service in specific descriptions, but their subsidiary spicula are often very suggestive of the nature and character of the species. Of this description, are the recurvo-ternate spicula in the interstitial cavities immediately beneath the dermal crust of some species of *Geodia*, and just without the dermal membrane of *Tethea cranium*; the remarkable groups of recurvo-quaternate spicula, represented by fig. 10, Plate XXX., Part II.; the trenchant bihamate spicula of *Hymedesmia Johnsoni*, figs. 1 & 2, Plate XXXI.; and many other instances of offensive or defensive spicula, either disposed in groups or singly, in these canals or cavities.

#### 9. *The Cloacal Cavities.*

The cloacal cavities are especially valuable and characteristic in the calcareous sponges. Their position, number, extent, and form—the number and position of their excurrent orifices—the mode in which those orifices are armed and the nature of that armature, or the entire absence of such defences—the internal defensive spicula, their varieties of form, and mode of arrangement,—all these characters are highly effective and valuable as specific descriptions. In other genera of sponges the cloacæ afford striking and very effective distinctions, especially in *Alcyoncellum*, *Polymastia*, *Halyphysema*, and *Hyalonema*. Among the Keratosa also they avail to a considerable extent; but the latter order does not afford us the same wide range of striking characters that exist so abundantly in the cloacæ of the order Calcarea.

#### 10. *The Sarcode.*

The universal presence and similarity in structure of the sarcode of the Spongiadæ renders the range of its use as a specific character very limited; but the spicula imbedded in its substance so abundantly in many species are so various in form, and so strikingly distinct from each other, as to afford a most valuable series of discriminative characters.

The greater portion of these spicula are more or less stellate in form. They vary in shape to a considerable extent in each group, in consequence of incomplete or complete development, and the number of the radii in the stellate forms is in many cases very uncertain; but although this amount of variation exists in each of the separate forms, there is always a limit to these differences, and a normal character present which renders it by no means difficult to decide to which class they belong. Independently of the peculiar characters of their own form and modes of radiation, their radii are fre-

quently peculiarly and abundantly spinous, and these secondary organs are equally as constant and determinative of specific character as the primary radii. The characters derived from the spines are frequently very minute, and require the application of a high microscopic power to render them available; but they are in many cases so decisively valuable, that they should never be neglected when present. In truth, the modes of spination of these and all other forms of spicula are of considerable value as specific characters, and the shape and direction of the spines are often indicative of the character and purpose of the spiculum on which they are based.

The range of the stellate spicula is very considerable. They are found abundantly and constantly in *Geodia*, *Pachymatisma*, *Tethea*, *Dactylocalyx*, and *Alcyoncellum*, and in some species of *Spongilla*, *Dictyocylindrus*, and other genera.

### 11. *The Ovaria and Gemmules.*

Where the ovaria exist they afford excellent descriptive characters. Their construction is the same throughout the whole of the known species of *Geodia* and *Pachymatisma*. The varieties in their form, although not always easy of description, are yet readily distinguishable by a practised eye; and the difference in the degree of stoutness of the radiating spicula of which they are constructed, and the consequent fineness or coarseness of the reticulations on their surface, very often afford good discriminative characters.

In *Spongilla*, the varieties in their shape, and the strikingly distinct forms of their component spicula, render them exceedingly efficient for specific descriptions; and without them it would in several instances, among the exotic species, be very difficult to find descriptive characters to separate one species from another.

Excepting in *Diplodemia*, where the structural peculiarities of the ovarium are widely different from the preceding instances, we know very little more of these organs; but there is good reason to believe, from certain forms of spicula detected in the deep-sea soundings, the sources of which are at present unknown, that other marine sponges possess ovaria with which we are at present unacquainted.

The gemmules afford very efficient specific characters in some species of *Tethea*; but in the greater number of Halichondroid genera, although frequently present in abundance, they agree so closely in structure with each other as to render them of very little use as specific characters.

We thus find that we possess eleven distinct varieties of organic specific characters, many of which are exceedingly prolific in materials for descriptive purposes. A long familiarity with them has assured me of their value, and of their constancy in each species. However protean the form and colour may be, the organic structures can always be recognized with certainty, provided the specimen under examination has been dried in the condition in which it has been taken from the sea. To the organic characters may be added the less definite and valuable ones of form and mode of growth, which,

although less to be depended on than the organic ones, are frequently of service in conjunction with them, as leading and suggestive in the first stage of investigation.

A dependence on the specific characters to be derived from form alone inevitably leads to erroneous conclusions. Thus, from trusting too implicitly to it in the descriptions of his species, Dr. JOHNSTON, in his 'History of British Sponges,' has made two species out of one in the case of *Dysidea fragilis*, the thin-coating form of this sponge being also described as *Halichondria areolata*. *Halichondria incrustans* has also been described a second time as *H. saburrata*. An elongated form of *Halichondria ficus* has also been again described as *H. virgultosa*. The type specimen of *Halichondria sevesa*, Johnston, in the British Museum proves to be merely a thin-coating variety of *Halichondria panicea*; and the type specimen of MONTAGU'S *Spongia digitata* in the possession of Professor GRANT, *Halichondria cervicornis*, Johnston, on being microscopically examined, proved not to be a sponge, but an alga. Numerous other instances of error arising from a dependence on form alone as a specific character might be cited; but those I have given above are sufficient to prove the ineligibility of so mutable a character unaccompanied by organic structure.

Nearly the whole of this extensive series of specific characters have hitherto not been applied in the descriptions of the Spongiadæ, excepting in my own manuscripts. This omission has occurred, not from any doubt of their value, but simply because they were unknown to naturalists. It now remains to be proved how they may be rendered available in future descriptions of those animals. I cannot, perhaps, better attain this end than by detailing the order and mode of employing them in the description of species contained in my own Manuscript History of the British Sponges. The following is the order in which these characters have been taken for examination and description:—

1. Form. 2. Mode of Growth. 3. Surface. 4. Oscula. 5. Pores. 6. Dermis, and Dermal Membrane and its Spicula. 7. Skeleton and its Spicula. 8. Connecting Spicula. 9. Defensive Spicula—external, internal. 10. Spicula of the Membranes—tension spicula, retentive spicula. 11. Sarcode and its Spicula. 12. Ovaria and Gemmules, and their Spicula.

Colour.

Habitat.

Condition when examined.

This order of description, or any other that the student may prefer, should always be adhered to, and no part of the specimen under examination that is present, and which affords specific characters, should be omitted in the description; so that, when no mention is made of particular organs or classes of spicula, it may be presumed that they are not present in the sponge in course of description. A certain portion of these characters are always available. Thus the skeleton, incurrent canals or cells, the sarcodous system, the dermal and interstitial membranes, the pores, and the oscula are always present, while the excurrent canals or the cloaca are occasionally absent. The inter-

marginal cavities, if present, are not always distinguishable; and the external and internal defensive organs are, either one or both of them, frequently absent.

Specific characters should always be of a positive nature, such as the presence and form of particular spicula or other organs. It is a great mistake in writing specific descriptions, to make the differences between species to consist of one or two striking essential characters only. Such a practice may answer tolerably well when there are but two or three species of a genus known; but it frequently occurs when new species are found, that they also have the most striking essential characters of the previously known ones equally strongly developed. Much confusion is thus likely to occur from this paucity of description; whereas, if the whole of the essential characters of each species be carefully investigated and accurately recorded when it is first characterized, that description will most probably suffice permanently to distinguish it as a species, however numerous the subsequently discovered members of the genus may be.

Differential characters should never be intermingled with essential ones in characterizing the species. They should be reserved for the amplified history; and here they are of much value, as they lead to the relative consideration of two or more nearly allied species, and frequently assist the student in their discrimination when the essential characters are minute or somewhat obscure.

In the description of species the adjectives long, short, stout, slender, &c., must always be understood as in comparison with the congenerous organs of the species under consideration, and not as in relation to any fixed standard of size.

In the description of a new species it should always be stated whether the characters are given from a dried specimen, or whether from one fresh from the sea, as it frequently happens that many of the *natural* characters become completely obliterated and sometimes reversed by drying; thus the surface smooth in the live state become villous when dried; inconspicuous oscula become conspicuous when contracted and dry, and conspicuous oscula are often destroyed by desiccation; and so on with other characters. It is therefore absolutely necessary that the condition of the specimen should be stated along with its description.

#### *On the Preservation and Examination of the Spongiadæ.*

The greater portion of specimens in natural history may be readily examined and their species determined in the field; but this is rarely the case with the Spongiadæ. It becomes necessary therefore to preserve them in such a manner as to effectually retain their natural characters for examination at some future period. Small specimens may be preserved in spirit of wine; but this destroys their colour. If they are not likely to be permanently lodged in the cabinet immediately, it is better that they should be laid on blotting-paper, or a soft cloth, to absorb as much as possible of the water from within them, and then dry them rapidly before a fire, or in a slack oven, without any previous washing in fresh water. By this mode they retain a sufficient amount of moisture and flexibility to allow of their being handled and operated on for examination

with impunity; but the amount of salt thus left within them will in time cause considerable mischief to the specimen. After such specimens have been once thoroughly dried and their examination has been completed, they may be plunged into cold water for a few minutes, and the water then ejected by a rapid centrifugal motion of the arm, and this operation repeated two or three times; the specimen should be again rapidly dried, and it will then keep well in the cabinet and preserve all its characteristic features. It is a bad habit to soak marine specimens for a considerable time in fresh water to extract the salt, as by this mode of proceeding the minute and delicate characters of the object are to a great extent destroyed.

The most advisable mode of proceeding, in the examination of an unknown species, is, first to note the general peculiarities of form and surface as presented to the unassisted eye. After the noting of the external character, the next step should be to cut a slice out of the sponge, to about half an inch or more in depth, at right angles to the surface, taking special care that a due proportion of the dermal membrane is included; this should be placed in a long narrow test-tube, in about an inch deep of nitric acid, in which it should be gently and cautiously boiled over a very small flame until the sponge is entirely dissolved, and then set by until the acid is quite cold and the spicula have subsided to the bottom of the test-tube, so that the greater portion of the acid may be decanted off and its place be supplied with distilled water; and this operation should be repeated three or four times with much care. The spicula thus prepared should be placed in a watch-glass with a little distilled water, and the whole stirred up so that an average sample can be obtained for microscopical examination. By this mode of procedure a general view of the whole of the spicula belonging to the species will be obtained, which will serve as a guide to the subsequent modes of examination.

The boiling in nitric acid should not be continued beyond the time of the piece of sponge falling completely separated to the bottom. If stopped at this period by the addition of a little distilled water, it frequently occurs that undissolved gemmules and portions of the membranes are found, that are very suggestive for the further examinations of the specimen.

The next step should be to take a thin slice from the surface of the sponge, and place it in a cell in a little distilled water, for the purpose of the examination of the structural peculiarities of the dermal membrane. Then take a thin slice from the body of the sponge at right angles to its surface, and mount it in a similar manner for the purpose of ascertaining the nature and peculiarities of its skeleton and other internal organs. These two sections should be carefully examined with the microscope; and if they be not sufficiently characteristic, fresh ones should be mounted. If the specimens thus treated be taken from sponges properly preserved, their tissues will expand and assume very much the appearance of those of the living sponge, and they will as nearly as possible exhibit the natural positions and proportions of the internal organs.

The general characters of these sections should be observed with a half-inch or two-

thirds combination, and again with not less than a quarter-inch object-glass, and the characters of the various tissues in their natural condition be immediately noted. But the whole of their minute organs will not be visible by this mode of examination; and it is therefore necessary to mount the same or similar sections in Canada balsam, by which means the spicula of the sarcode and other minute organs will become completely visible *in situ*; and the specimens thus mounted will serve as permanent records for the cabinet.

The following are a few examples of the mode of specific description that I propose for adoption by naturalists who may investigate the Spongiadæ.

GRANTIA CILIATA, Fleming.

*G. ciliata*, Johnston.

*G. pulverulenta*, Johnston.

Sponge elongately oval, rarely globular, slightly pedicelled; surface papillated, hispid. Cloaca central, cylindrical, nearly as long as the sponge; armed internally with spiculated equiangular triradiate spicula; spicular ray attenuated. Mouth of the cloaca armed with a thick ciliary fringe of very long and slender acerate spicula; base of the fringe supported by large, short and stout fusiformi-acerate spicula. Oscula simple, very slightly depressed from the surface of the cloaca, as numerous as the interstitial cells. Pores inconspicuous. Interstitial cells: distal terminations more or less obtusely conical, furnished with a ciliary fringe of slender acerate spicula. Skeleton-spicula equiangular triradiate.

Colour cream-white.

*Hab.* Coasts of Great Britain; parasitical on fuci; littoral to 8 or 10 fathoms or more.

Examined alive.

PACHYMATISMA JOHNSTONIA, Bowerbank.

*Halichondria Johnstonia*, Trans. Mic. Soc. London, vol. i. p. 63, pl. 6; Johnston's Hist. Brit. Sponges, p. 198.

Sponge massive, sessile; surface smooth, undulating into ridges. Oscula simple, congregated on the elevations. Pores inconspicuous. Dermis crustular, filled with ovaria. Dermal membrane pellucid, abundantly spicular; spicula fusiformi-cylindrical, tuberculated, minute. Intermarginal cavities immersed in the dermal crust, separate, symmetrical, subcylindrical, valvular at proximal end. Connecting spicula attenuato- or cylindro-ternate; radii variable in form and proportions. Skeleton-spicula cylindrical, variable in form and proportions. Spicula of sarcode attenuato-stellate; radii incipiently spinous, rarely fully spinous, or obtuse. Ovaria oval, depressed.

Colour: littoral specimens light to dark slate-grey; deep-sea specimens pink or red. (Captain F. W. L. THOMAS, R.N.)

*Hab.* Rocks between high and low water mark. Torquay. Gouliot Caves, Sark. Coast of Ireland (J. S. BOWERBANK). Orkney Islands, thirty-five fathoms (Captain F. W. L. THOMAS, R.N.). Wick, Scotland (C. W. PEACH).

Examined in the live state.

TETHEA CRANIUM, Lamarck.

*Tethea cranium*, Johnston.

Sponge ovoid or subspherical, sessile surface even, strongly hispid. Dermal coat thick, abundantly furnished with short, stout, fusiformi-acerate spicula surrounding the large defensive fasciculi at various angles to their axes; also profusely furnished with minute sigmoid bihamate spicula, dispersed irregularly. Dermal membrane thin, pellucid. Oscula and pores inconspicuous. Spicula of the skeleton fusiformi-acerate, large and long. Defensive spicula external, collected in fasciculi; fusiformi-acerate, large and long, fusiformi-porrecto-ternate, and a few fusiformi-recurvo-ternate very long and slender. Sarcode abundantly furnished with minute sigmoid bihamate spicula. Gemmules lenticular, surface smooth, very tough and strong; of two distinct sorts: the first furnished abundantly with slender fusiformi-acerate spicula radiating in fasciculi from the centre to near the surface of the gemmule; the second furnished abundantly with slender fusiformi-acerate, slender unihamate attenuated, and with short slender porrecto-ternate spicula, mixed in fasciculi which cross each other irregularly.

Colour pallid green.

*Hab.* Island of Fulah (JAMESON). Haaf Banks, Shetland (BARLEE and BOWERBANK).

Examined in the fresh state.

In the specimens of specific descriptions which I have given above, there are fortunately numerous characteristic points by which we may readily separate them from their congeners; but this abundance of characters does not always exist. Thus in *Halichondria caduca* we find the structures so few and simple, as to render their description exceedingly difficult and unsatisfactory.

HALICHONDRIA CADUCA, Bowerbank.

Sponge massive, sessile, surface rugged. Oscula simple, small, dispersed, numerous. Pores inconspicuous. Dermal membrane aspiculous, pellucid, thin. Spicula of skeleton acerate, rarely acute. Interstitial membranes thin, translucent; spicula acerate, slender. Sarcode abundant.

Colour light grey.

*Hab.* Tenby (Mrs. BRETT).

Examined in the dried state.

Fortunately these cases of extreme paucity of characters are very few in number.

## EXPLANATION OF THE PLATES.

## PLATE LXXII.

- Fig. 1. *Grantia*. A longitudinal section of a portion of one side of a specimen of *Grantia ciliata*, exhibiting the structure and mode of disposition of the interstitial cells,  $\times 108$  linear: page 1093: see also Part II. Plate XXXIII. fig. 1, for interstitial cells.
- Fig. 2. *Leucosolenia botryoides*. Two branches exhibiting the simple fistulose structure of the sponge,  $\times 50$  linear: page 1094.
- Fig. 3. *Leuconia nivea*. A longitudinal section of one of the mammiform portions, exhibiting one of the great cloacal cavities of the sponge and its internal defensive spicula,  $\times 50$  linear: page 1094. 3 a, figure of a sponge, natural size.
- Fig. 4. *Leucogypsia Gossei*. A section at right angles to the surface, exhibiting the mass of irregular interstitial structure,  $\times 50$  linear: page 1095.
- Fig. 5. *Geodia Barretti*. A section at right angles to the surface, exhibiting the radial disposition of the fasciculi of the skeleton, and a portion of the dermal crust of the sponge,  $\times 50$  linear: page 1098.
- Fig. 6. *Pachymatisma Johnstonia*. A section at right angles to the surface, exhibiting the irregularity of the interstitial structures directly beneath the dermal crust,  $\times 50$  linear: page 1101.

## PLATE LXXIII.

- Fig. 1. *Ecionemia acervus*, Bowerbank, MS. A section at right angles to the surface, exhibiting the radial fasciculi of the peripheral system, with the ternate apices of the spicula directly beneath the dermal membrane,  $\times 50$  linear: page 1101.
- Fig. 2. *Polymastia robusta*, Bowerbank, MS. A view of a small portion of the side of one of the large cloacæ, exhibiting the structure and mode of disposition of the longitudinal skeleton-fasciculi,  $\times 25$  linear: page 1104.
- Fig. 3. *Halphysema Tumanowiczii*, Bowerbank, MS. A complete sponge, based on the stem of a Zoophyte, exhibiting the irregular longitudinal disposition of the skeleton-spicula,  $\times 175$  linear: page 1105.
- Fig. 4. *Ciocalypa*. Representing a longitudinal section through the central axis of one of the elongate cloacal portions of the sponge, exhibiting the central column with the small cylindrical pedicels or short fasciculi of closely packed spicula, each terminating at the inner surface of the dermis of the sponge, natural size: page 1105.
- Fig. 5. A section of the specimen represented by fig. 4, at about the middle of the

cloacal column, exhibiting the mode of the radiation of the distal ends of the small pedicels on the inner surface of the dermis,  $\times 25$  linear: page 1105.

Fig. 6. *Tethea Lynceurium*. Section at right angles to the surface, exhibiting the corymbose mode of expansion of the radial fasciculi of the skeleton near the surface of the sponge,  $\times 50$  linear: page 1106.

Fig. 7. *Dictyocylindrus ramosa*. A section through the axial column, showing the elongo-reticulate structure of the skeleton of the sponge,  $\times 50$  linear: page 1108.

Fig. 8. *Diplodemia vesicula*. A small portion of its compound reticulate skeleton, exhibiting the intermixture of the spiculo-reticulate skeleton with the heterospiculate fibrous one,  $\times 108$  linear: page 1117.

#### PLATE LXXIV.

Fig. 1. *Phakellia ventilabrum*. A longitudinal section of one of the primary radial lines of skeleton structure, exhibiting the slender secondary radiation of the skeleton,  $\times 50$  linear: page 1108.

Fig. 2. *Microciona atosanguinea*. Exhibiting the columnar structure of the skeleton,  $\times 108$  linear: page 1109.

Fig. 3. *Hymedesmia Zetlandica*. Exhibiting the disjoined fasciculi of the skeleton *in situ*,  $\times 108$  linear: page 1110.

Fig. 4. *Halicnemis patera*. A portion of a section at right angles to the surface, exhibiting the mode of disposition of the spicula of the skeleton,  $\times 25$  linear: page 1107.

Fig. 5. A portion of the same section, taken at *a*, fig. 3,  $\times 108$  linear: page 1107.

Fig. 6. *Hymeniacidon caruncula*. Exhibiting the dispersed condition of the skeleton spicula on the interstitial membranes of the sponge,  $\times 108$  linear: page 1111.

Fig. 7. *Halichondria incrustans*. Exhibiting a better type of the skeleton structure of the genus than *Halichondria panicea*,  $\times 50$  linear: page 1113.

Fig. 8. *Isodictya Normani*. Exhibiting the regular and nearly rectangular structure of the network of the skeleton of spicula,  $\times 108$  linear: page 1114.

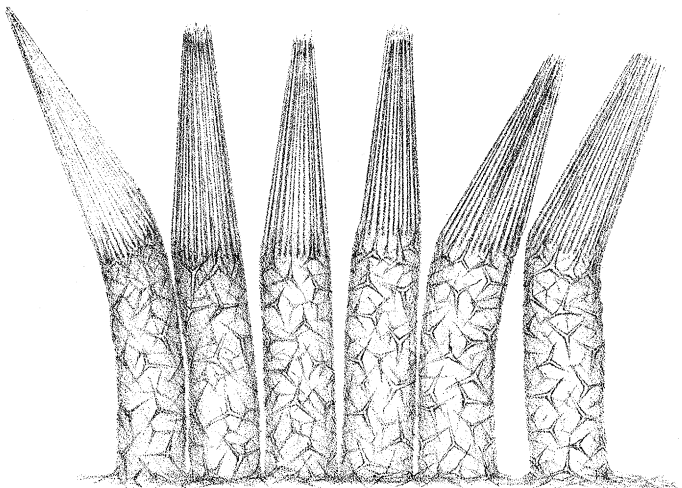
*Spongilla*. Agrees perfectly in the structure of the skeleton with *Isodictya*, but is distinguished from that genus by the peculiarities of the reproductive organs. See figures of *Isodictya*, Plate LXXIV. fig. 8, page 1115.

Fig. 9. *Spongia*. Showing the irregularity of the disposition of the keratose fibre,  $\times 50$  linear: page 1119.

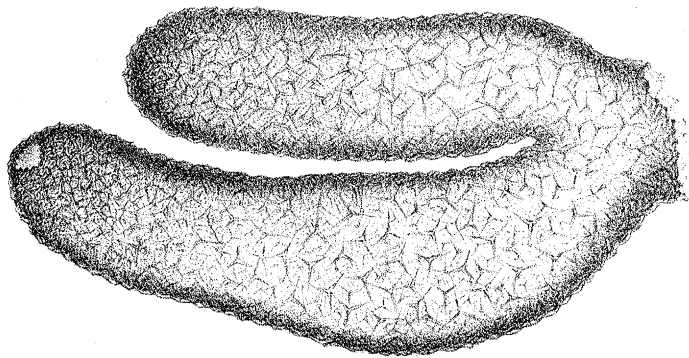
Fig. 10. *Spongionella*. Exhibiting the nearly rectangular mode of disposition of the primary and secondary keratose fibres of the skeleton,  $\times 50$  linear: page 1119.

Fig. 11. *Halispongia*. Showing one of the large primary keratose fibres, containing siliceous spicula, and the irregular system of small aspiculous keratose fibres,  $\times 175$  linear: page 1120.

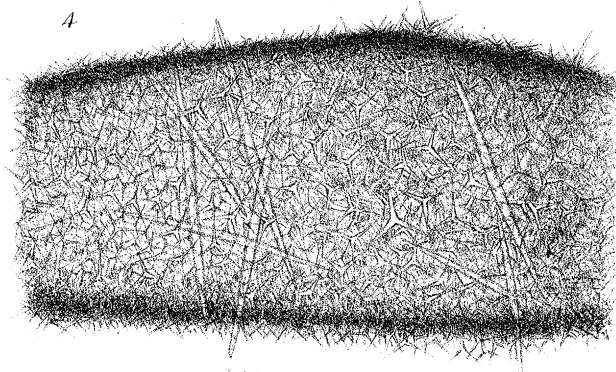
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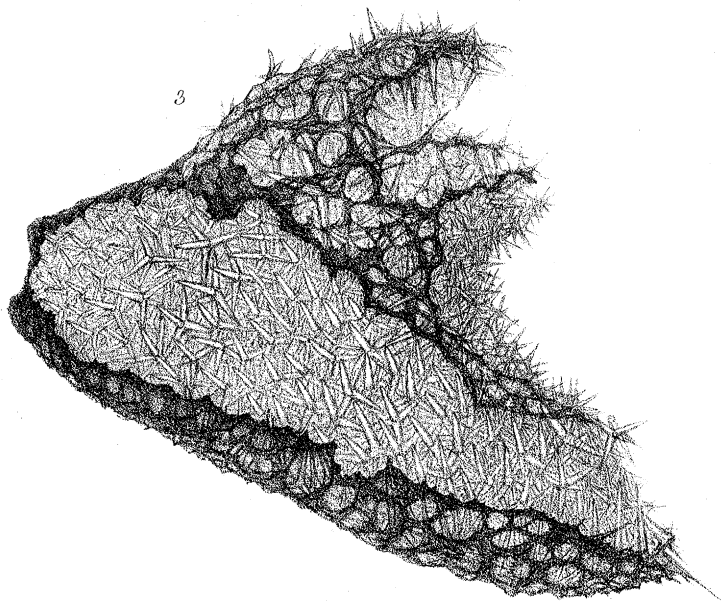
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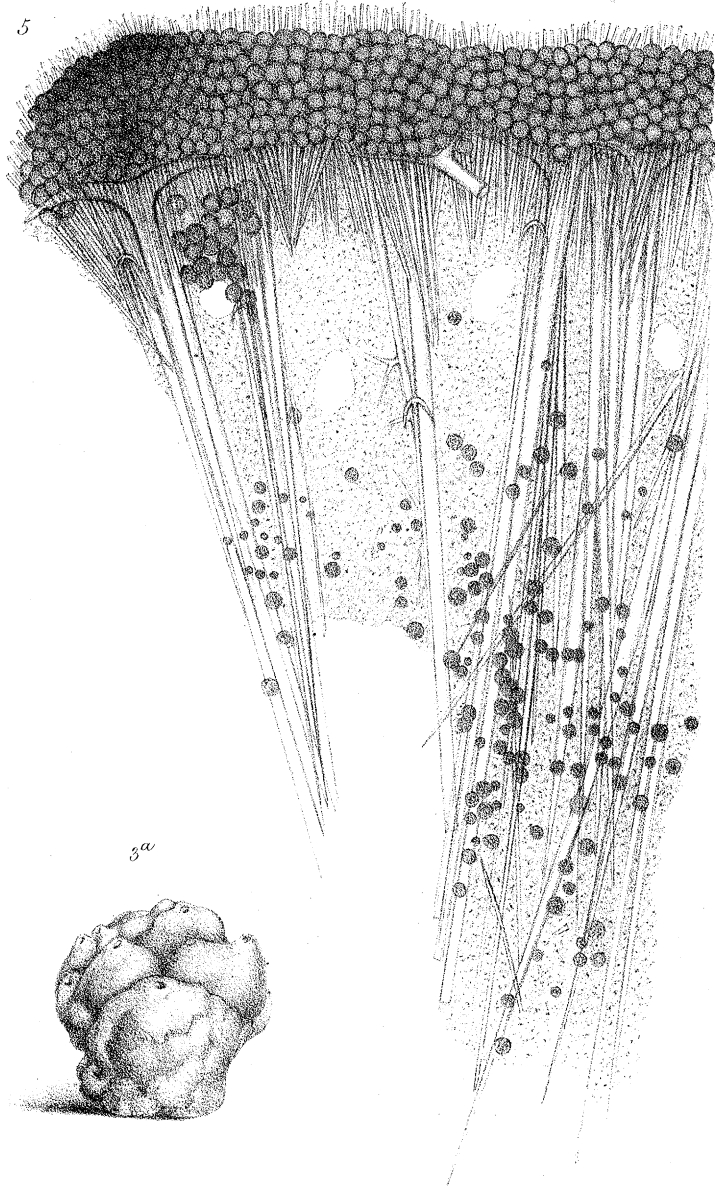
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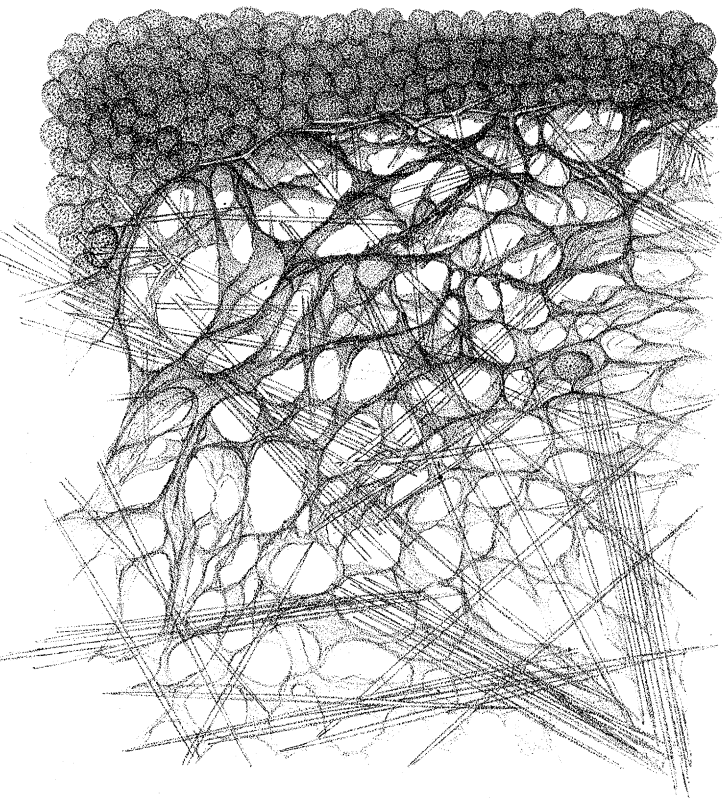
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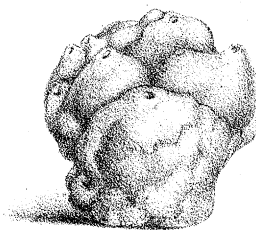
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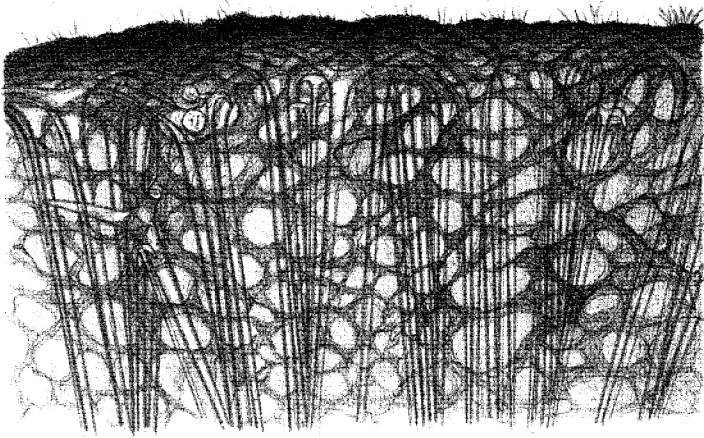
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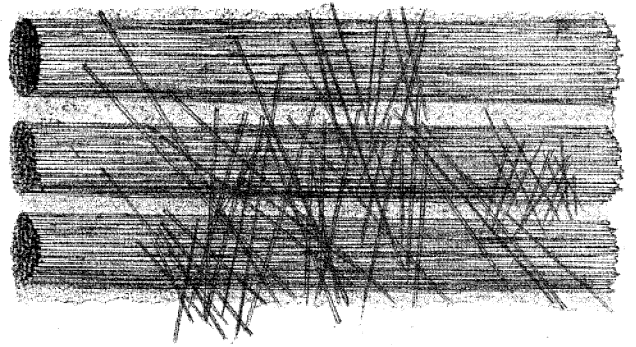
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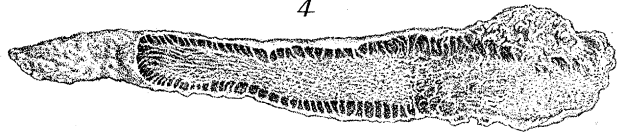
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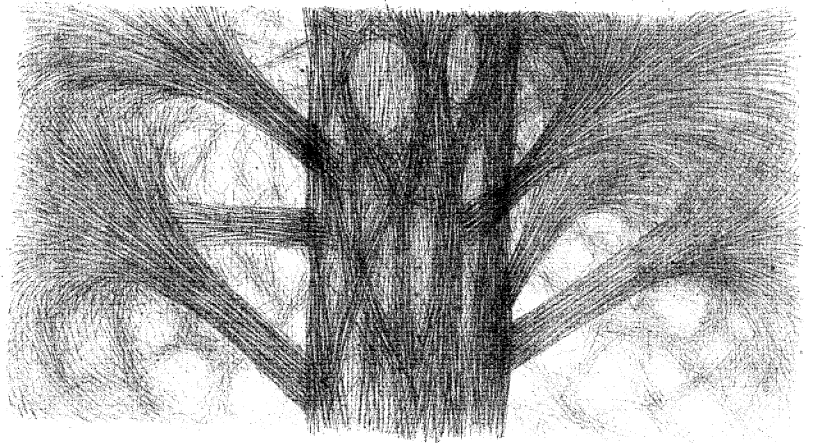
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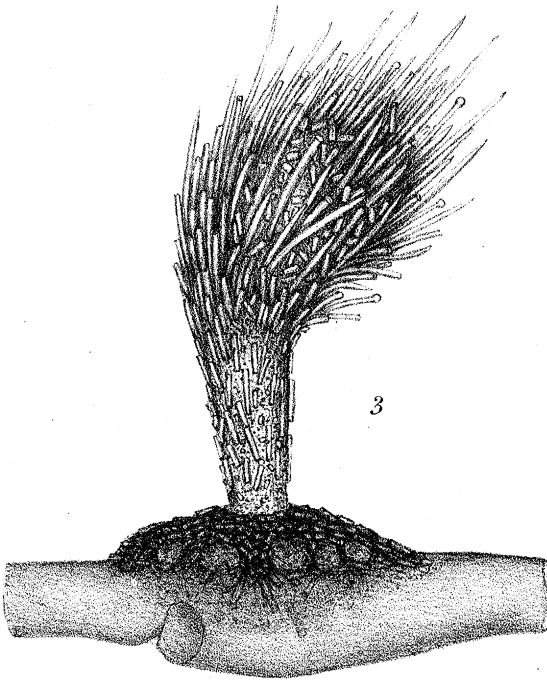
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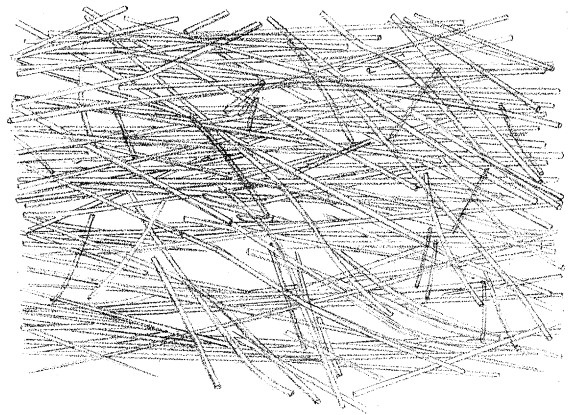
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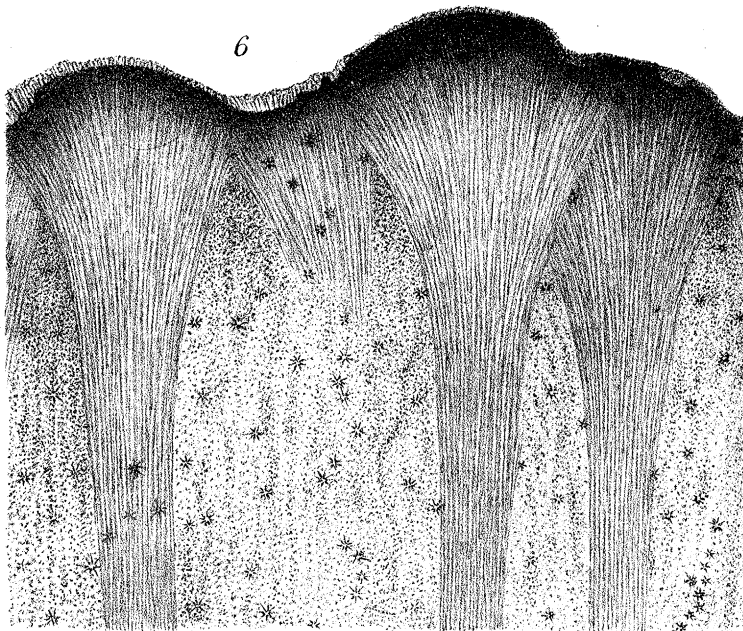
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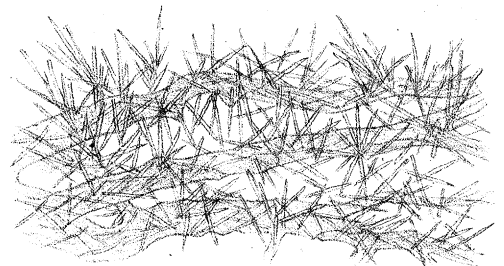
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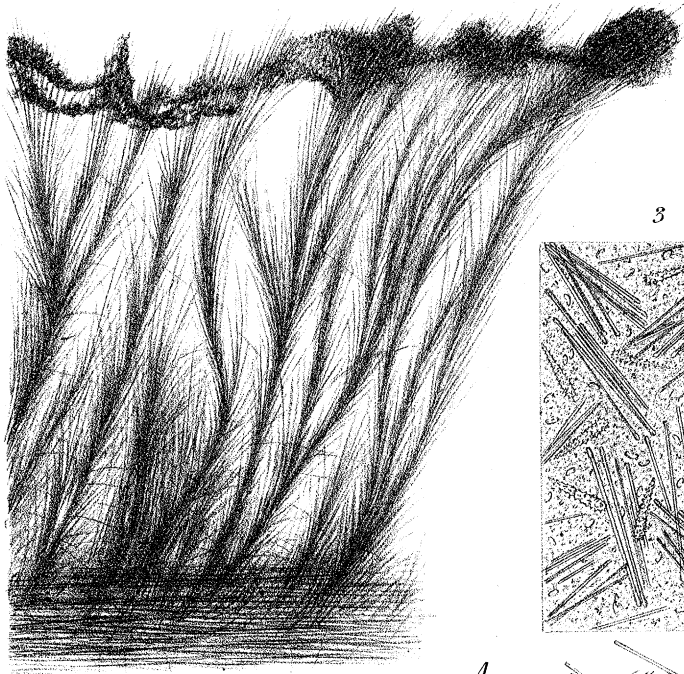
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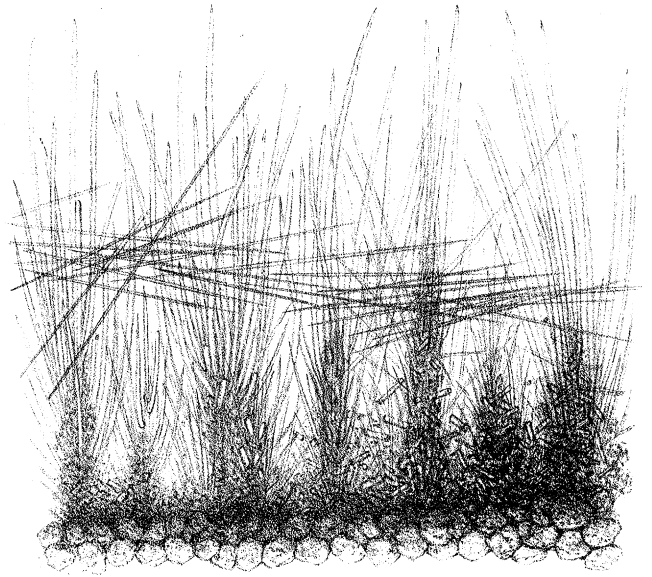
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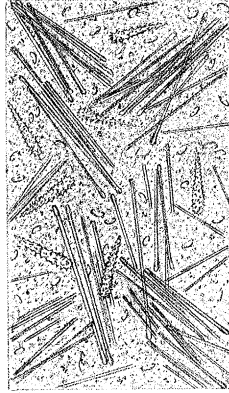
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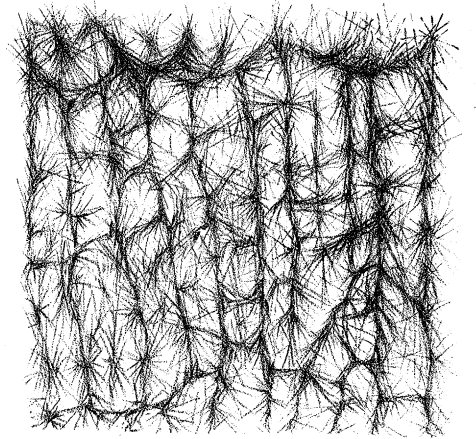
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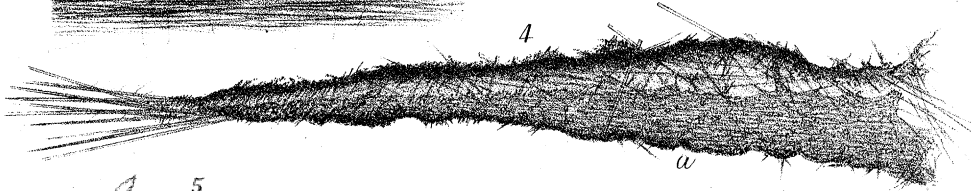
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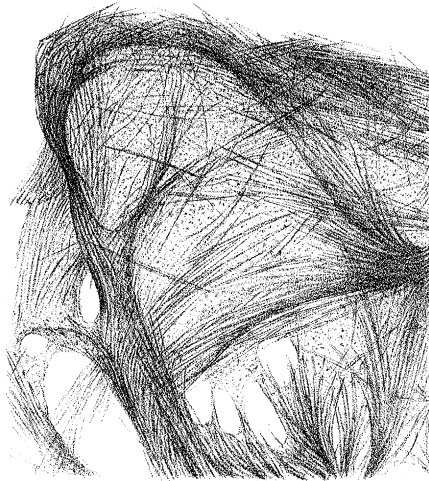
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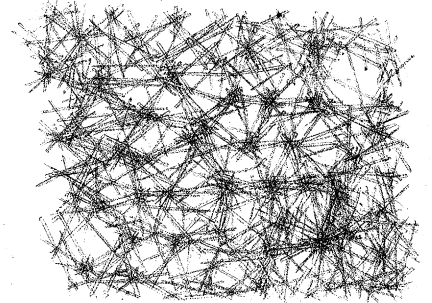
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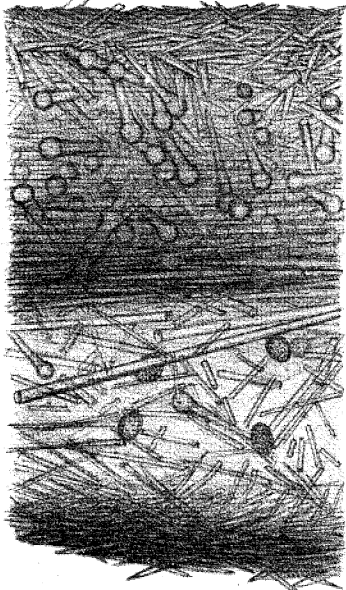
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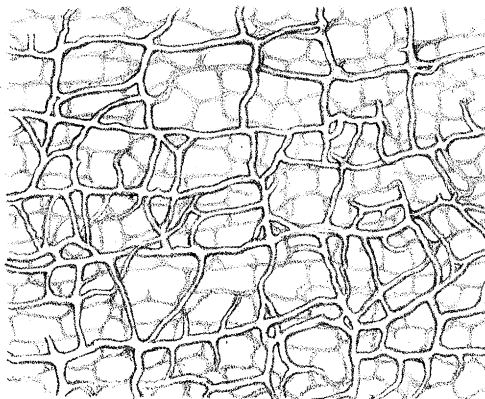
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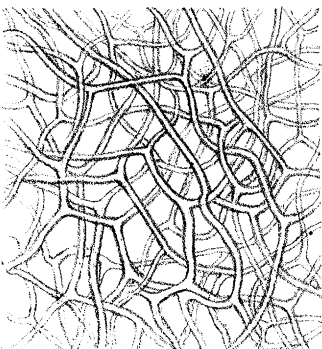
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